Volume VII, 2012

Explorations

The Journal of Undergraduate Research and
Creative Activities for the State of North Carolina

www.uncw.edu/csurf/explorations/explorations.html

csurf@uncw.edu

Center for the Support of Undergraduate Research and Fellowships
UNCW Honors College
Randall Library
University of North Carolina Wilmington
Wilmington, NC 28403

Cover photographs:
"Charlie's Bunion-GSMNP" © Bill Atwill
"Autumn at Shallowford Lake" © Justin Davis
"Mason's Inlet Sunset" © Bill Atwill

ISBN: 978-0-9849000-4-6

Original Design by The Publishing Laboratory
Department of Creative Writing
601 South College Road
Wilmington, North Carolina 28403
www.uncw.edu/writers

UNCW
UNIVERSITY of NORTH CAROLINA WILMINGTON
Center for the Support of Undergraduate Research and Fellowships

HONORS COLLEGE

THE PUBLISHING LABORATORY
UNIVERSITY OF NORTH CAROLINA WILMINGTON

Staff

2012 Board of Reviewers

Masum Akond, PhD
Research Fellow of Plant Genomics & Biotechnology
Fayetteville State University

William Atwill, PhD
Associate Director of Honors
Associate Professor of English
University of North Carolina Wilmington

Yufang Bao, PhD
Assiantant Professor of Math & Computer Science
Fayetteville State University

Steven Benko, PhD
Assistant Professor of Religious & Ethical Studies
Meredith College

Gary L. Callahan, PhD
Music Department Chairman
Livingstone College

Shirley Chao, PhD
Associate Professor of Biology
Fayetteville State University

Maurice Crawford, PhD
Assistant Professor of Biology
Elizabeth City State University

Francie Cuffney, PhD
Professor of Biology
Meredith College

Samantha Daniel, PhD
Professor of Psychology
Fayetteville State University

Nicola Davis-Bivens, EdD
Assistant Professor of Criminology
Johnson C. Smith University

Michael Funk Deckard, PhD
Assistant Professor of Philosophy
Lenoir Rhyne

Miriam DeLone, PhD
Professor of Crimical Justice
Fayetteville State University

James Denniston, PhD
Professor of Psychology
Appalachian State University

Elizabeth Denny, PhD
Professor of Psychology
University of North Carolina at Pembroke

Wade Dudley, PhD
Associate Professor of Teaching
East Carolina University

Cynthia Edwards, PhD
Professor of Psychology
Meredith College

Kim Epting, PhD
Associate Professor of Psychology
Elon University

Chad Everhart, MA
Associate Professor of Technology
Appalachian State University

Mary Farwell, PhD
Professor of Biochemistry
East Carolina University

Susan Fecho, MFA
Professor of Art
Barton College

Nicholas Freeman, PhD
Assistant Professor of Psychology
University of North Carolina at Pembroke

Jim Gaston, MPM
Director, Duke Smart Home Program
Duke University

Candace Gauthier, PhD
Professor of Philosophy and Religion
University of North Carolina Wilmington

Glen Anthony Harris, PhD
Associate Professor of History
University of North Carolina Wilmington

Avis Hatcher-Puzzo, MFA, MS
Assistant Professor of Dance
Fayetteville State University

Thomas Hennessey, PhD
Associate Professor of Government and History
Fayetteville State University

Jennifer Horan, PhD
Associate Professor of Public & International Affairs
University of North Carolina Wilmington

Leslie Hossfeld, PhD
Professor of Sociology
University of North Carolina Wilmington

Daniel Johnson, PhD
Associate Professor of Music
University of North Carolina Wilmington

Eric Jones, PhD
Research Scientist of Anthropology
University of North Carolina at Greensboro

Heather Koopman, PhD
Associate Professor of Marine Biology
University of North Carolina Wilmington

Melanie Lee-Brown, PhD
Associate Professor of Biology
Guilford College

Nicole Lucas, PhD
Assistant Professor of Sociology
Fayetteville State University

Mark Marquez, PhD
Assistant Professor of Social Work
Fayetteville State University

Gail Marsal, PhD
Assistant Professor of Criminal Justice
North Carolina Wesleyan College

Jaime A. Martinez, PhD
Assistant Professor of History
University of North Carolina at Pembroke

Mike Maume, PhD
Professor of Sociology and Criminology
University of North Carolina Wilmington

Mark McCallum, PhD
Professor of Biology
Pfeiffer University

Joseph Moore, PhD
Professor of Social Sciences
Gardner-Webb University

Beth Mulvaney, PhD
Professor of Art
Meredith College

Nora Noel, PhD
Professor of Psychology
University of North Carolina Wilmington

Hyunju Oh, PhD
Assistant Professor of Mathematics
Bennett College

Rick Olsen, PhD
Associate Professor of Communication Studies
University of North Carolina Wilmington

Maria Orban, PhD
Associate Professor of English
Fayetteville State University

Jesse Peters, PhD
Professor of English and American Indian Studies
University of North Carolina at Pembroke

Will Pizio, PhD
Assistant Professor of Justice and Policy Studies
Guilford College

Bob Poage, PhD
Associate Professor of Biology
University of North Carolina at Pembroke

Brian Railsback, PhD
Dean, Honors College
Professor of English
Western Carolina University

Sharon Raynor, MA
Associate Professor of English
Johnson C. Smith University

Sue Richardson, PhD
Senior Lecturer of Film Studies
University of North Carolina Wilmington

Chadwick Roberts, PhD
Lecturer of Communication Studies
University of North Carolina Wilmington

Tom Schmid, PhD
Professor of Philosophy and Religion
University of North Carolina Wilmington

Tsvetanka Sendova, PhD
Professor of Mathematics and Computer Science
Bennett College

Anthony Snider, PhD
Assistant Professor of Environmental Studies
University of North Carolina Wilmington

Jaclyn Stanke, PhD
Associate Professor of History
Campbell University

Tatiana Tagirova, PhD
Assistant Professor of Language, Literature and Communications
Elizabeth City State University

Dan Teague, PhD
Instructor of Mathematics
North Carolina School for Science and Mathematics

Thomas Tiemann, PhD
Professor of Economics
Elon University

Linda Tomlinson, DAH
Assistant Professor of History
Fayetteville State University

Molly Weise, PhD
Associate Professor of Sociology
North Carolina Wesleyan College

Rufus Williamson, PhD
Associate Professor of Math and Science
Livingstone College

Sara Wrenn, PhD
Assistant Professor of Psychology
Bennett College

Taek You, PhD
Assistant Professor of Biology
Campbell University

With special thanks and appreciation to the faculty mentors and volunteer reviewers.

Table of Contents

Letter from the Editor

We are pleased to present volume VII of *Explorations, the Journal of Undergraduate Research and Creative Activities for the State of North Carolina.* Again this year, the number of submissions was at a record level. We are especially pleased to feature creative works this year, and hope that trend continues.

This year we include seventeen papers and three creative pieces, selected from thirty-one submissions. The topics range from historical and philosophical perspectives to biological experiments to innovations in biotechnology to mathematical modeling to psychological and sociological research. Nine public and private schools are represented, including the NC School of Science and Mathematics.

It is useful each year to provide a bit of background about *Explorations*. In 2005, the State of North Carolina Undergraduate Research and Creativity Symposium, affectionately known as SNCURCS (pronounced "Snickers") was first held, and educators from all colleges, universities, community colleges, and high schools were invited to participate. Now in its 8th year, SNCURCS offers a venue for undergraduates to present their research and creative efforts. *Explorations* was the brainchild of the 2005 meeting, and we are thankful that Michael Bassman and East Carolina University organized and published the first three volumes. In 2008, the late George Barthalamus, former Director of Undergraduate Research at NCSU and the visionary behind our state-wide undergraduate research efforts, talked me into moving *Explorations* to UNCW in time to produce the 2009 volume, and we have now published four volumes at UNCW. At UNCW we are fortunate to have a very successful Publishing Laboratory that developed the current look of *Explorations*, plus I have a great team of students who have done the layout for the recent issues. This year, I am indebted to Ms. Jamie Watson and the Honors College Media Board team who produced the layout for *Explorations*. Jamie, thank you for those overtime and weekend hours!

I am also very appreciative of the effort that the sixty-two ad hoc reviewers spent providing timely and thoughtful reviews of the papers this summer.

So in the spirit of the excitement that fresh approaches to research and discovery bring, we offer you volume VII of *Explorations*.

Katherine E Bruce, PhD

Biology and Biotechnology

History of Passive Solar Energy

Scott Barber
East Carolina University
Faculty Mentor: Michael Behm
East Carolina University

ABSTRACT
Passive solar design, an idea within the growing trend of green building, is a creative way to use the sun to our advantage, both for heating and cooling, based on the design of buildings. As green building has continued to become more popular, many changes have been made to make the design and construction of our buildings more environmentally and economically sustainable. This review focuses on the development in passive solar applications, from its earliest appearances in ancient Greek buildings to current designs that take advantage of radiation convection or acrylic panels. There have been many passive solar developments that can be explored, and the innovative technology today has brought about great advancements in the past few decades alone. This review presents a compilation of information from a variety of sources that provide knowledge regarding the history of passive solar energy. As the popularity of green building continues to grow, it is essential to develop an understanding of passive solar design, and other green building techniques, in order to be equipped for the years to come.

Passive solar systems are used to "collect, store and distribute thermal energy by natural radiation, conduction and convection through sophisticated design and wise selection of building materials" [9]. This definition, provided by J.K. Paul, sufficiently explains that the idea of passive solar energy is the use of natural processes, such as radiation, conduction, and convection, to distribute thermal heat provided by the sun. Passive solar energy also involves blocking the sun's rays in order to provide cooling during the summer. Incorporating solar energy into our buildings will decrease the amount of money we spend on energy as well as extend the time other sources of energy will last.

Due to increasing oil prices, rising gas prices have become a common sight not only in the United States, but around the world. The exploitation and misuse of our natural resources is rapidly depleting our oil and natural gas. This type of deterioration is not only evident in natural gas, but also in many other common sources of energy. Though many are aware of the decreasing amount of oil, most people assume there is an endless supply of coal, nuclear, and other energy sources. It has been estimated that there is enough coal to last about 250 more years[14], enough oil to last approximately 44 years[5], and nuclear fuel to last 23 years[12], if the cost is kept somewhat higher. Even if these numbers are a low estimate, and enough energy sources remain for several more centuries, there is still a need to find cleaner sources of energy. What many people are unaware of is the damage that our current energy sources cause to the environment[4]. The pollution and other byproducts of manufacturing usable energy from these raw materials have dramatically affected not only the atmospheric quality, but they have also damaged the surrounding ecosystems,

whether they are forests, prairielands, or water habitats. Ron Jones, an architectural expert for sustainable building, explains that humans have begun to further explore and understand the relationship between the built environment and the natural environment. In the past, we simply were concerned about the effect of nature on buildings, but now are realizing the impact our buildings have on the environment. This is the key to sustainable design[6].

There is a plethora of renewable energy sources that provide energy that is much better for the environment. While the mining and burning of coal and uranium leads to smog, acid rain, and air toxins, renewable energy, including solar, wind, hydropower, geothermal, or even renewable materials such as agricultural products or biomass, results in little, if any, pollution. These types of renewable sources are becoming a pivotal aspect of the increasingly popular "green" movement. There are three parts of being green: being acceptable economically, ecologically, and socially. These three pillars make up the sustainability movement, and help direct decisions so that processes and materials used are suitable in each of these areas. For example, when installing wind turbines, to completely fit within sustainability, one must take into consideration these three ideas to ensure that the turbines will be economically efficient, environmentally friendly, and socially acceptable. While a wide variety of renewable sources exist, they are not developed enough currently to provide materials and systems that are beneficial within the three pillars of sustainability. However, one type of renewable energy does have the necessary progress to be used and still be considered sustainable: passive solar energy. While many people are aware of active solar energy systems, such as solar panels, passive solar energy is a division of solar energy that uses the sun's energy in a more natural manner. It is also helpful to understand specific savings in cost for buildings that use passive solar energy. According to a document provided by Appalachian State University, a passive solar home could save as much as $160 per year by using simply using movable insulation and low-emissivity glass, glass that radiates low levels of radiant thermal energy [11].

In this paper, I overview the history of passive solar design as well as review and analyze technological information regarding the use of solar energy. The goal of this review is to inform the reader of historical passive solar energy uses and to explain in greater detail what passive solar energy is and how it is applied.

CATEGORIZATION OF PASSIVE SYSTEMS

To have a better understanding of passive solar energy, it is helpful to know how to categorize passive systems used for this type of solar energy. While there are specific techniques and systems that use the sun's energy in a passive way, they are all defined as being either direct gain, indirect gain, or isolated gain.

Direct gain is the simplest application of passive solar energy, where the space of the building is directly heated by the sunlight, which most often enters through windows within the south-facing wall for buildings in the northern hemisphere[7]. Ideally, in this approach, the materials within that space ought to be capable of storing heat and the air flow throughout the room should distribute the heat. A representation of direct gain is shown in Figure 1, which also depicts the difference of the angle of the sun during the summer and winter, and how an overhang can be incorporated into the building design for further temperature control.

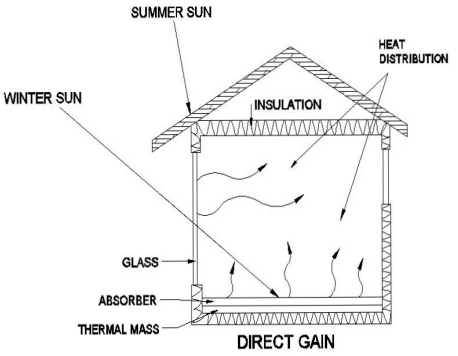


Fig. 1. Direct gain passive solar energy.

For indirect gain, sunlight is most often received by a south-facing wall, and as air moves throughout the internal space, the heat will then be transferred from the wall to the living space[7]. For increased control of indoor temperature, ventilation at the top and bottom of the wall or other thermal mass is included, assisting in regulating the temperature. Figure 2 clearly displays indirect gain, the use of a thermal mass for solar heat gain, as well as vents integrated into the thermal mass for air circulation and heat distribution.

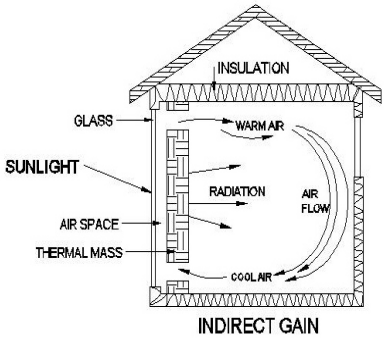


Fig. 2. Indirect passive solar energy. Thermal wall with ventilation for airflow and temperature regulation.

Isolated gain, depicted in Figure 3, uses solar collection and thermal storage that are separate from the actual living space, moving heat to the living space through natural or forced convection. Ventilation is also essential in this method of passive solar heat gain. An advantage to isolated gain systems is that they can be added to new and existing buildings[2].

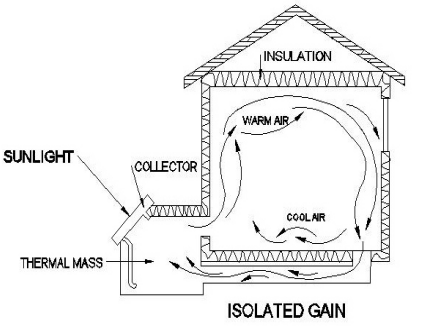


Fig. 3. Isolated gain passive solar energy.

Regardless of the type of heat gain utilized, passive solar energy provides heat at little to no cost, aside from the slight variations in the design and construction of the building.

HISTORICAL APPEARANCES OF PASSIVE SOLAR

Solar power has benefited civilizations for centuries, and the knowledge from our past provides foundational understanding of the sun's energy to bring about our current understanding of solar power. The earliest known application of solar energy arose during the 15th century B.C. by the Egyptian ruler Amenkotep III, who "supposedly possessed 'sounding statues' that operated when the air in their base pedestals expanded after exposure to sunlight"[3]. Though this was merely

an accomplishment of aesthetic value, solar energy has also been used to distill water as well as dehydrate agricultural plants. Solar energy has been used in even more advanced, practical ways by many civilizations to provide heat for homes, light fires, and even cauterize wounds. In the 5th century A.D., Socrates realized that "in houses that look toward the south, the sun penetrates the portico in winter, while in summer the path of the sun is right over our heads and above the roof so that there is shade"[8], and that initiated the use of solar energy to heat homes.

Though the first recorded application of solar energy is in the 15th century B.C., the next appearance wasn't for several hundred years, where the historian, Plutarch, documented that virgins used cone-shaped metal objects to start ritual fires during the 7th and 8th centuries B.C.[3]. During this time the sun was used to distill water and dehydrate agricultural plants. A famous use of solar energy, while the event is still surrounded with reservations and disbelief, occurred in 212 B.C., when Archimedes used a "burning mirror" to set invading Roman ships on fire. A similar story was recorded in the 12th century, where Proclus, a Greek, supposedly accomplished this achievement during the siege of Constantinople when the Bitellius fleet was invading, using many mirrors.

While there is no sure way to know whether or not these feats happened, the recording of this event sparked much curiosity, and soon more applications of the sun's energy were being recorded in history. For example, in 77 A.D. Romans used "burning glasses" to cauterize wounds and light fires[3]. Another one of the earliest applications of passive solar energy was in the Roman atrium and heated bathhouses in the first through the fourth centuries, where large south facing windows let in the sun's warmth to heat the pool[9]. Solar energy became so well-known in the 6th century A.D., that the Justinian Code commenced "sun rights" in order to guarantee everyone would have access to the sun. The last known use of solar energy before the 1700s appears in North America. The Anasazi Native Americans built their homes in the side of the cliffs in what is now known as the Colorado Plateau, where Utah, Colorado, Arizona, and New Mexico meet[9]. These south-facing buildings were placed within the side of the cliff to avoid the sun in the summer, but make use of the sun during the winter. It is clear that there was an early understanding of using the sun for energy, and this knowledge and technology surrounding it increased significantly beginning in the seventeenth century.

Up to that point in history, through the 1200s, passive solar energy was used by Egyptians, Greeks, Persians, Hindus, and the Native Americans, following ancient architectural teachings of Aristotle, Xenophon, and Vitruvius [9]. In the ancient historical appearances of passive solar energy uses, the architecture was geared towards using the sun and wind to alleviate the extremes of the climate, but due to a lack of glass, they were unable to utilize the sun to the extent we can today. However, though most ancient civilizations lacked glass and other technology that we use today, they still made significant progress and provided understanding and a good foundation for future developments regarding the use of solar energy.

Beginning in the 17th century, interest grew in regards to using the sun as an energy source, and though there was not a large amount of development within passive solar techniques, significant progress was made in active solar systems. The increased awareness of solar energy brought about by the experimentation with solar energy served also to make people conscious of the use of solar energy passively, as well, though there isn't as much historical recording of passive solar energy during this time. In

regards to active solar energy systems, the first "solar engine" was invented in 1615 by Salomon de Caux. This engine used glass lenses to heat up an airtight metal vessel with water and air to produce a small water fountain[3]. Though this lacked practical use, it is significant because it was the first published documentation of solar energy after the fall of the Roman Empire. Also in the 17th century, physicist Athanasius Kirchas experimented with starting fire with mirrors, and German mathematician Tschirnhaus worked with lens-type items to concentrate solar energy to melt various materials[3]. Overall, the 17th century included various experiments from different specialists who sought practical applications of solar energy.

In the 18th century, there was more experimentation from many various professionals around the world. French scientist George Buffon worked to determine whether or not the Archimedean feat could have been accomplished, and determined that setting ships on fire was possible, but not very probable considering the lack of technology in 212 B.C.[3]. Another Frenchman, Claude Poillet, provided significant information that would assist in the development and application of both active and passive solar energy. He determined the intensity of the sun in reference to the geographical position, and it is this association which has been regarded "at least as important in solar utilization as the hardware itself"[3]. It was in 1767, just a few decades later, that the first solar collector was invented, built by Horace de Saussure, a Swiss scientist. This collector was used to heat food, and was used by Sir John Herschel in the 1830s, during his expedition in South Africa[13]. There continued to be a variety of research and investigation in regards to solar energy during this time, all providing more information that would serve useful in years to come.

It was in the late 19th century that passive solar energy began appearing more often and in more noteworthy means. In 1880, theories surrounding solar houses began to appear, and it was in Salem, Massachusetts that the idea of a glazed, south-facing wall, as well as incorporating the requirements for air flow between the glazing and the wall first arose. Not only that, but professor E.L. Morse was approved for a patent "for the combination of a dark colored massive wall, an air space, glazing…and adjustable dampers by which the flow of air could be controlled"[9].

A few years later, in 1896, the thermosyphon water heater was invented, the oldest and most widely used passive solar device in the world, which was utilized in World War I in Southern California to provide hot water to army camps[9]. Many other southern states adopted this technology, as well as Japan and Australia, but the extension of natural gas lines and the cheap availability of electricity resulted in a nearly complete elimination of its use. However, due to increased prices in other energy sources for providing hot water, this device and its "active but similar offspring," and the forced circulation solar water heater, are beginning to be used more[9]. These new developments provided more information, but also created specific ways that passive solar energy could be implemented into people's daily lives. For example, a home built in Massachusetts was one of the greatest steps in passive solar design during the last few centuries, providing a concrete and successful use of passive solar energy. Overall, the 1800s provided more research in solar energy than perhaps any other time in history. However, the following centuries resulted in a greater diversification of the applications and uses of solar energy.

MODERN DEVELOPMENTS

Since the twentieth century, there has been a great variety of fairly modern passive solar developments. Though the deliberate practice of using solar energy for heating within buildings was apparently forgotten outside of agricultural, the 1930s reintroduced this practice in the relatively colder climate of Minnesota[1]. The sudden increase in the application of and interest in passive solar energy was a result of sealed, insulating windows becoming available at a much more reasonable cost. Due to the necessity of windows within the application of many passive solar techniques, easily available windows allowed passive solar methods to appear in residential architecture just before World War II[9]. The Keck brothers in Chicago were forerunners within the new appearances of passive solar energy, providing prefabricated buildings in the 1940s. These buildings used large, south-facing windows with overhangs to admit sunshine in the winter but block it in the summer months. They also included flat roofs that were made to be flooded during the summer to decrease the amount of solar heat gain[9].

Though these and similar houses were being designed and constructed, they lacked the full potential and were less effective, mainly because the common heating and cooling systems were readily available at a much lower cost. Another notable progression within solar energy use in homes was the book entitled Your Solar House, funded by Libbey-Owens-Ford Glass Company. This book included forty-eight designs for homes to utilize direct gain solar energy, one design for each state within the United States at that time[9]. Again, these designs were not ideal applications of solar energy, primarily because there was no consistent way to control temperature within the buildings. In various adaptations and improvements that were made to these designs, double glazing, windows that could be opened, and ventilating fans were used to maintain comfort. Unfortunately, there was a slight break in research and development concerning solar energy during World War II, even though there were still companies practicing these methods.

After World War II, despite the revival of interest regarding solar heating, most people were focused more on active systems for solar energy and therefore passive solar heating was largely neglected. The American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE), however, continued to research the gain of solar heat through window placement, which has provided foundational information for today's strategies for determining solar heat gain through windows, and has resulted in multiple direct gain passive solar houses in New Mexico[9].

These homes implemented newer technology which improved them significantly from their fairly inefficient predecessors built in the 1930s and 1940s. For example fairly consistent temperatures were gained through concrete or adobe floors which absorb heat. Also, movable insulation protected the house in times of exceptionally cold weather or when there were extended days where clouds blocked the sun[9]. The improvements in these structures significantly increased their practicality and effectiveness.

In the decades following, there were continued discoveries and inventions regarding solar energy. In 1954 photovoltaic technology was first revealed, as Daryl Chapin, Calvin Fuller, and Gerald Pearson invented the first solar cell that converted energy from the sun to provide electrical power. The following year, Western Electric began selling licenses for silicon photovoltaic technologies. It was during

this time that architect Frank Bridgers designed the first commercial office building that used solar water heating and other passive solar designs[13]. It is worth noting that these passive solar systems are still in operation within this building today, and this office building has been recognized in the National Historic Register as the world's first solar heated office building.

Since these improvements, the most noteworthy addition to passive solar energy is the Trombe wall. Developed by Frenchman Felix Trombe, based on the work of Edward Morse in the 1880s, this wall faces the sun and essentially absorbs the sun's heat and releases it inside the building at night[9]. Aside from slight alterations, most passive solar techniques have remained the same and have only varied in regards to application. Figure 4 shows a modified Trombe wall that utilizes a glazing material to collect solar heat and vents to provide air flow and distribute the heat to the interior room. This type of Trombe wall is a very efficient way to take advantage of passive solar energy.

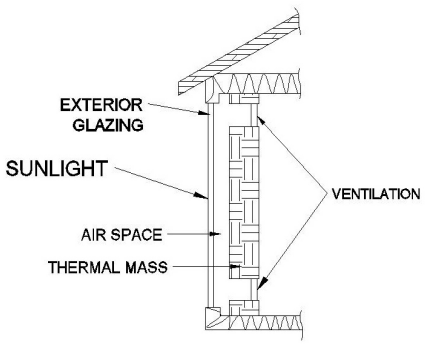


Fig. 4. Modified Trombe wall using exterior glazing and air vents for air flow.

A noteworthy aspect of passive solar design is the many programs and organizations devoted to encouraging, monitoring, and rewarding sustainable building. In 1985, Austin Energy, located in Austin, Texas, was the first residential energy efficiency program[6]. In 1991, this organization further developed and became known as Austin Energy Green Building®. Since that time, many more programs have begun, such as the Advanced Energy Corporation located in Raleigh, NC, the Southface Energy Institute in Atlanta, GA, and the Solar Living Institute in Hopland, CA. In 1995, the United States Environmental Protection Agency began the Energy Star program, which evaluates the energy use and efficiency of buildings. Since the Energy Star program is limited to energy, the United States Green Building Council (USGBC) was founded in 1993 and within that, the Leadership in Energy and Environmental Design (LEED) program was founded in 1998[6]. These programs have proved a key role in encouraging and rewarding sustainable design, including passive solar energy practices.

PASSIVE SOLAR APPROACHES

Although there are many different aspects of passive solar energy as well as the three pillars for producing sustainable passive solar energy, there are five basic approaches to forming these types of passive systems: direct gain, thermal storage walls, solar greenhouses, roof ponds, or convection loops. These techniques can be either direct gain, indirect gain, or isolated gain, based on how they collect, store, and transmit thermal energy [9]. These methods are a result of the extensive research and advancements throughout many centuries, bringing us to the understanding we have today, allowing us to use the sun's energy efficiently and responsibly.

Direct gain is the simplest application of passive solar energy, and as such is the most popular. Direct gain is beneficial because it is not only simple, but it also has a relatively

low cost. However, direct gain struggles because it cannot control temperature as effectively due to of a lack of thermal storage. Other potential problems that may arise include undesirable lighting during the day such as glares, as well as discoloring of fabrics due to extensive ultraviolet rays[2].

The second common approach to passive solar energy involves using a thermal storage wall, which essentially uses a material that absorbs the sun's heat after it has passed through the glazing. The wall may be black or another dark color to assist in its absorbing, or it may even consist of water held in masonry or other containers[2]. Regardless of the absorbing material, its purpose is to absorb the temperature and release it into the interior room. This assists in controlling temperature and reducing temperature extremes, as well as reducing the negative effects of direct gain: glare or undesirable lighting and material damage due to the ultraviolet light. While direct gain can heat up a room much quicker, it is much more difficult to control, which is a benefit of using a thermal storage wall. Often, windows are included in this wall to combine direct gain with the thermal storage to incorporate the benefits of both[7].

Using a roof pond is the third common approach to passive solar techniques[2]. It may or may not include the physical presence of water on the roof, but where there is not water present, movable insulation is required on the roof. Essentially, this technique relies on gathering solar heat through the roof, but with insulation that prevents too much heat from collecting during the hotter summer months [2]. There have also been studies and research in New Mexico and Arizona, testing various active and passive systems to control the amount of heat transferred through the roof. This type of system would be used for a flat roof, ideally, and could serve beneficial for both heating and cooling by adding or removing the insulation during summer and winter, or day and night.

The final approach for passive solar techniques is the convective loop, which uses a thermo siphon, a machine that circulates water, to move heat from the collection point to a storage area. Water heaters often use this idea, as it is very inexpensive and reliable, more so than many other types of water heaters commonly known. This system works well without needing pumps or controls[9]. Air convention loops often combine passive collection/storage with active distribution to provide a simple but effective system to provide temperature control for a building.

Overall, these five types of applications of passive solar energy can be very beneficial to include in many different climates and situations. When applying these ideas to buildings, it is important to be aware of the strengths and weaknesses of each of these applications. It also may be very feasible to combine a variety of these approaches in order to utilize their strengths and develop a well-rounded passive solar building.

The majority of all passive solar energy techniques are applied during the planning and construction process of the buildings, because the most important aspect of a building is its location and direction. However, there are a few options that provide heating from solar energy for pre-existing buildings. By adding larger windows or double-glazed, low-emittance windows on the south wall, passive solar energy can be utilized. The double-glazed, low-emittance windows have the ability to allow heat to enter into the building but reduce the amount of heat lost to the outside. Also, planting deciduous trees, trees that shed their leaves in the winter, on the south side of a home will provide shade from the sun during the summer but allow the sunlight to enter into the windows

during the winter. Blocking in windows on the north side of a home may also assist in solar heating, though doing so may not be aesthetically pleasing.

PASSIVE SOLAR ENERGY: IS IT WORTH IT?

While passive solar energy is growing in popularity within the green movement and has improved significantly in the last few decades, there are still doubts surrounding its viability and effectiveness. The primary arguments that are made in favor of using passive solar energy are divided into economic, architectural, and comfort/health categories. In general, passive solar energy is very beneficial because it is inexpensive and has little, if any, impact on the environment.

When observing the economic aspects of passive solar design, it is important to remember that each building is different, depending on construction and materials used. However, the benefit to passive solar energy, as opposed to active solar energy or other types of renewable sources, is that it requires no additional cost for upkeep; the costs are the same as the general maintenance costs of any building. It is possible to save money long-term simply by taking passive solar systems into consideration for the design process[6]. Changing the direction of the structure alone, in order to gain more heat from the sun on the southern part of the building, can make a huge difference in collecting solar heat. Essentially, passive solar energy only requires a slight increase in cost, if any increase at all, to incorporate these systems into the design and construction of the building.

In terms of temperature within the building, some people may be hesitant to use this technology, mainly because it isn't easy to control the temperature of a room which is dependent on passive solar for heating or cooling. However, pairing up passive solar aspects with a back-up heating system, shading devices or operable windows will greatly increase the amount of control one has in regards to temperature[2]. Also, passive solar heating also maintains a warmer floor, which is desirable. Most heating systems used today can lead to large floor-to-ceiling temperature differences, resulting in discomfort at the floor level. On the contrary, passive solar systems use materials that absorb heat, and therefore the floor is warmer and more comfortable[2].

One of the greatest attractions of passive solar energy is the fact that it is very environmentally friendly; it is a renewable energy source and does no damage to the environment around it[6]. By using passive solar energy rather than a common heating or cooling system, there is a great reduction in the consumption of fossil fuels and the production greenhouse gases and other pollutants[6]. Overall, passive solar energy has few disadvantages and its advantages are both economical and environmentally friendly.

FUTURE TRENDS

While there has been a dramatic amount of progress and development throughout history regarding passive solar energy, by observing where technology is today, one can only wonder how much more progress can be made. While there certainly will be improvements in materials, it appears that the techniques have currently reached a plateau. However, when asked "What is it that we really require from scientists and technologists?" economist E.F. Schumacher provided guidance into the improvements of passive solar energy: "We need methods and equipment which have the following characteristics: they are cheap enough so that they are accessible to virtually everyone, they are suitable for small scale

applications, they are compatible with man's need for creativity, and they are not heavily dependent on natural resources"[10]. Passive solar energy certainly has the potential for meeting these requirements.

The design of passive solar buildings, based on the materials and technologies available today, will remain consistent for the next several decades. The strategies and techniques being used today will be replicated in various ways depending on location and availability to maximize the benefits of passive solar energy. One can assume that when new technologies arrive, the design of passive solar buildings will adapt to incorporate them to maximize their efficiency. However, the specific design for buildings regarding passive solar energy has climaxed for the present time.

The further development of passive solar energy is reliant on new technologies and the development of more appropriate, efficient resources. One of the newest developments that will continue to grow and improve passive solar use involves window glazing. Low-emittance coatings, known as low-E coatings, are metallic oxide films that are installed on windows to reduce from within the building while still allowing solar heat gain. These coatings do not affect the visual aesthetics of the window, yet provide valuable benefits. There are also double-glazed windows filled with argon gas, which provide the same benefits as the coatings on the windows and can be used together to increase efficiency. As these technologies continue to improve, passive solar energy will become more beneficial and effective.

It is also important, however, to recognize the role that green building programs will serve in the continuation and expansion of passive solar practices. Certifications and recognition within these programs are available for the buildings being constructed, the professionals who design, build, and remodel those buildings, and the products used for the buildings as well[6]. With this in mind, passive solar practices within sustainable design will become more common, and industry leaders around the world will incorporate sustainable practices. It is important for the future of passive solar design that those involved in the design and construction of buildings to be certified in sustainable design, for resources and products used to be sustainable, and as a result, the structures will be more sustainable as well.

CONCLUSION

Throughout history, mankind has benefited from and worked to harness the sun's energy in order to create a more enjoyable living space and save energy. Solar energy has been used for centuries and has only improved with time, as researchers and scientists have developed processes and materials to improve the quality and effectiveness of solar energy. Using solar energy, specifically passive solar energy, is a very cost efficient way to take steps towards sustainability, and as the green movement continues to develop and expand, passive solar techniques will be utilized more and more throughout the United States and in nations around the world. It is helpful to realize the history in regards to passive solar energy, and the benefits that can be gained by applying passive solar energy.

Overall, the various types of passive solar energy have unique strengths and weaknesses. Direct gain, the simplest application of passive solar energy, provides quick, economically friendly, inexpensive heating for a home. The main disadvantage is its difficulty in providing adequate control of the environment. Indirect gain, a slightly more complicated use of passive solar energy, goes beyond direct gain and offers a more stable environment with better heat control. However, indirect gain requires greater planning and also takes longer to heat up a room or home. The third

application, isolated gain, delivers even more control and stability in controlling the indoor environment. This, too, requires further planning and is more expensive to construct.

The five strategies used for passive solar energy, direct gain, thermal storage, solar greenhouses, roof ponds, and convection loops, all have their own advantages and disadvantages as well. The main drawback to implementing these strategies into a building is a need for further planning and specific materials. However, this increased initial cost only increases the long-term savings for a building using passive solar energy. The use of these approaches to passive solar energy requires an evaluation for each building in regards to feasibility and usefulness. They can certainly be useful in many applications, and are worth considering in the planning process.

Passive solar energy will continue to grow and change, providing inexpensive, sustainable alternatives for common heating and cooling systems. As technology improves and awareness increases, passive solar energy will become more widely used throughout the country and around the world. It is certainly a viable option for new construction, and will continue to assist in saving energy for many.

REFERENCES

1. Aronin, J. E., Climate and Architecture, Reinhold, New York, p. 66-90, (1953).

2. Bainbridge, D. A., & Haggard, K. (2011). Passive solar architecture: Heating, cooling, ventilation, daylighting, and more using natural flows. White River Junction, NV: Chelsea Green Publishing.

3. Cheremisinoff, P. N., & Regino, T. C. (1978). Principles and applications of solar energy. Ann Arbor, MI: Ann Arbor Science.

4. Gabel, M. Earth, energy and everyone. California: Straight Arrow Books, 1975.

5. Gregory, Shirley Siluk. (2011, March 7). How much oil is left? Retrieved from http://www.greenbang.com/how-much-oil-is-left_16795.html.

6. Kruger, A., & Seville, C. (2013). Green building: Principles & practices in residential construction. Clifton Park, NY: Delmar, Cengage Learning.

7. Mazria, E. (1979). The passive solar energy book. Emmaus, PA: Rodale Press.

8. Passive solar design-a history. (n.d.). Retrieved from http://www.greenbuilding.com/knowledge-base/passive-solar-design-history.

9. Paul, J. K. (1979). Passive solar energy design and materials. (41 ed.). Park Ridge, NJ: Noyes Data Corporation.

10. Schumacher, E. F. (1999). Small is beautiful: Economics as if people mattered. Point Roberts: Hartley & Marks.

11. State Energy Office. (2005, June). Affordable passive solar planbook for North Carolina. In Energy center: Appalachian State University. Retrieved March 22, 2012, from http://energy.appstate.edu/sites/energy.appstate.edu/files/APSplanbook.pdf.

12. Union of concerned scientists. (2009, November 30). Retrieved from http://www.ucsusa.org/clean_energy/coalvswind/c02c.html.

13. U.S. Department of Energy: Energy Efficient & Renewable Energy. (2007, May 28). U.S. department of energy. Retrieved from http://www1.eere.energy.gov/solar/pdfs/solar_timeline.pdf.

14. U.S. Energy Information Administration. (2011, October, 11).U.S. energy information administration independent statistics & analysis. Retrieved from http://www.eia.gov/energyexplained/index.cfm?page=coal_reserves.

Microbial Kinetics of *Photorhabdus luminescens* in Glucose Batch Cultures

Matt Bowen
University of North Carolina at Pembroke
with **Danica Co,** *William Peace University*
Faculty Mentors: Len Holmes** with **Floyd Inman
University of North Carolina at Pembroke

ABSTRACT
Photorhabdus luminescens, an entomopathogenic bacterial symbiont of Heterorhabditis bacteriophora, was studied in batch cultures to determine the specific growth rates of the bacterium in various glucose concentrations. P. luminescens was cultured in a defined liquid medium containing various concentrations of glucose. Culture parameters were monitored and controlled utilizing a Sartorius stedim Biostat® A plus fermentation system. Agitation and air flow remained constant; however, the pH of the media was chemically buffered and monitored over the course of bacterial growth. Measurements of culture turbidity were obtained utilizing an optical cell density probe. Specific growth rates of P. luminescens were determined graphically and mathematically. The substrate saturation constant of glucose for P. luminescens was also determined along with the bacterium's maximum specific growth rate.

1. INTRODUCTION

Photorhabdus luminescens is a Gram-negative, bioluminescent,entomopathogenic bacterium that is found to be a bacterial symbiont of the nematode *Heterorhabditis bacteriophora* (Inman, Singh and Holmes, 2012). These symbiotic partners serve as a bacto-helminthic complex that is considered to be a safe alternative to chemical insecticides. Through symbiosis and entomopathogenicity, these organisms are capable of infecting a broad range of insect hosts belonging to the orders of Coleoptera, Diptera, and Lepidoptera (Ehlers and Hokkanen, 1996). The infective juveniles of *H. bacteriophora* carry many cells of the bacterial symbiont in their upper digestive tract and upon entrance into the insect hemocoel; the juveniles regurgitate the cells into the insect hemolymph.

As the cells proliferate, they produce biomolecules (toxins and digestive enzymes) that kill and bioconvert the insect host into nutritional components for both organisms (Boemare, Laumond, and Mauleon, 1996). Furthermore, *P. luminescens* secretes pigments and antimicrobials to ward off other contaminating microbes and as a result, ideal conditions are created for nematode growth and development (Waterfield, Ciche and Clark, 2009).

The symbiotic relationship between *H. bacteriophora* and *P. luminescens* is very intimate and complex as both partners are needed to support each other in many aspects. In this relationship, infective juvenile nematodes provide their bacterial symbionts with: 1) protection from environmental conditions; 2) a route to gain access to "food" (e.g. insect hemolymph); and 3) a mode of transportation from host to host. On the other hand, *P. luminescens* provides many benefits to its nematode partner such as: 1) protection from insect immunity, 2) growth

factors from bioconversion of the insect; 3) production of antimicrobials that protect the insect cadaver from other invading organisms; 4) secretion of "food signals" that induce nematodes to develop; and 5) being the main food source. It is of worth to mention that this relationship may not sound like a true mutualistic association; however, the parasitism and pathogenicity refer to the effects of these two organisms (nematode and bacteria, respectively) on their primary host, the young insect larvae.

The mass production of nematodes for biocontrol purposes must incorporate the use of mid to large-scale fermentation systems along with optimized media that will support survival of the nematodes along with their bacterial symbionts for extended periods of time. Because *P. luminescens* is the main food source for the nematodes, it is crucial that the mass production medium be pre-inoculated with *P. luminescens* prior to nematode inoculation (Inman, Singh and Holmes, 2012). Furthermore, researchers also suggest that *P. luminescens* secretes a "food signal" that triggers the infective juveniles to continue their development (Strauch and Ehlers, 1998). Therefore, bacterial cultures at high cell densities are required to obtain maximum recovery of infective juveniles (Ehlers, Lunau, Krasomil-Osterfeld and Osterfeld, 1998).

In their paper, Jeffke et al. (2000) studied the growth of *P. luminescens* in glucose batch and fed-batch cultures. However, the authors did not report the necessary information needed to obtain a basic understanding of glucose utilization for this bacterium. The information needed to determine kinetics of glucose utilization includes specific growth rates of the bacterium at different glucose concentrations and the substrate saturation coefficient (Ks) for glucose. Furthermore, the researchers utilized an undefined medium for their research. Without the employment of a defined medium, determination of glucose utilization is extremely difficult as the undefined medium contains other sources of utilizable carbon. Therefore, it is the main objective of this study to determine the microbial kinetics of *Photorhabdus luminescens* in batch cultures containing synthetic media. To obtain the necessary information for glucose utilization, batches of defined media were supplemented with different initial glucose concentrations. This investigation complements previously performed research (Jeffke et al., 2000) and also provides more information about glucose utilization in *P. luminescens*.

2. MATERIALS AND METHODS

2.1 Organisms and Media

Infective juvenile nematodes of *Heterorhabditis bacteriophora* were obtained from Arbico Organics, Tuscan, AZ and used to infect larvae of *Galleria mellonella* according to Inman and Holmes (2012). Isolation of the symbiotic bacterium, *Photorhabdus luminescens*, from the hemolymph of nematode-infected larvae of *G. mellonella* was performed as described by Ehlers, Stoessel and Wyss (1990). The nutrient agar used in this study contained (g/L): beef extract, 5; digested gelatin, 3; trehalose dihydrate, 15; and agar, 15. Isolated, red pigmented, bioluminescent colonies were upscaled to 3 mL broth tubes and finally to 100 mL shake flask containing nutrient broth. The composition of the nutrient broth was the same as nutrient agar with the exception of agar.

2.2 Equipment and Software

A two liter Sartorius stedim Biostat® A plus fermentation system and its associated software was used to control and monitor process parameters. The Sartorius stedim BioPAT® MFCS/DA 3.0 software was used to record and export the process

data. A Mettler Toledo 405-DPAS-SC-K8S/200 gel filled combination electrode was utilized to monitor pH. An optek-Danulat, Inc. ASD19-N optical density probe and fermentor control module was used to measure and record culture turbidity in the near infrared range of 840-910 nm. Microsoft® Excel (2007) was used to graphically approximate the specific growth rates of each glucose batch culture based upon culture turbidity.

2.3 Fermentation Media

Liquid media for both overnight and experimental cultures were based on the defined media formulation of Bleakley and Nealson (1988). The composition of the liquid media contained (mM): NaCl, 50; $MgSO_4$, 5; urea, 30; L-proline, 10; Na_2MoO_4•2H2O, 0.025; $MnCl_2$•$4H_2O$, 0.025; $FeCl_3$•$6H_2O$, 0.025; HEPES, 50; KH_2PO_4, 100; and various glucose concentrations. Media components were prepared in deionized water and autoclaved within the appropriate vessels with the exception of glucose and potassium phosphate stock solutions, which were sterilized separately. During preparation of the medium components, the volumes of glucose and phosphate stocks needed to achieve the final media concentration of each were taken into account when preparing the other components. Prior to inoculation, the required volumes of each stock solution were aseptically added to the reactor. All solutions where adjusted to a final pH of 7.50 with 5 M KOH. The concentrations of glucose utilized in this study ranged from 1.8 mg/L to 198 mg/L. Proline is utilized in the kinetics medium as it: 1) acts as an osmoprotectant within insect hemolymph (Nealson, Schmidt, and Bleakley, 1990); 2) is believed to be a signal for regulation of phase I characteristics (Seydel, Lieb, Ehlers and Röck., 2000; Kontnik, Crawford and Clardy, 2010); and 3) is a requirement for *P. luminescens*. The bacterial strain used is a proline auxotroph as determined by initial shake flask cultures.

2.4 Process Setup and Parameters

Agitation of each batch culture was achieved with Rushton turbine stirrers set as a fixed rate of 100 rpm. Each batch was sparged with air at a constant flow rate of 1 vvm; while the process temperature was maintained at 28°C. Upon process equilibrium, the reactor was inoculated from a fresh 24 hour overnight of P. luminescens at a concentration of 1.67% of the media volume. Each overnight culture was cultivated in the defined medium containing minimal glucose concentrations to minimize excess glucose in the experimental media.

2.5 Analysis of microbial growth

2.5.1 Graphical approximations of specific growth rates

Turbidity data (time and concentration units) were downloaded from the data logger of the fermentor control module and imported into Microsoft® Excel as follows: Column A – time (h) and Column B – concentration units (cu). In Column C, the natural logs of the respective concentration units (ln cu) were calculated and entered utilizing Excel's natural log function. Data from Columns A and C from each batch were graphed into a single scatter plot.

Upon visual observation of the natural log curve, the exponential phase is seen as the sharp increase in the natural log data. Data points on the natural log curve that begin and end this phase are used as reference points as they are used as the limits for creating the linearized exponential phase, which is added to the same plot. A linear regression is performed on the natural log data between and including the limit

points. The line of best fit is determined for this linearization and the slope of this line reflects the specific growth rate for each batch under their respective conditions.

2.5.2 Calculations of specific growth rates

According to Stanbury, Whitaker and Hall (2003), the simplified equation for describing the exponential phase is shown in Equation (1), where x is the concentration of cells; t is time, in hours; and μ is the specific growth rate, reported as hour -1.

$$\frac{dX}{dt} = \mu X \quad (1)$$

Because this equation is fitted to utilize cellular concentrations (biomass, cell numbers, etc.) it must be slightly modified to fit culture turbidity (Widdel, 2010). In theory, culture turbidity or optical density (OD) is directly proportional to cellular density (Equation (2)); where N is cell number and V is unit volume. However, a proportionality factor (α) is needed to accurately convert the cellular density into OD (Equation (3)). Therefore, the proportionality factor and the OD can be substituted for X in Equation (1) to become Equation (4)

$$\frac{N}{V} \sim OD \quad (2)$$

$$\frac{N}{V} = \alpha \cdot OD \quad (3)$$

$$\frac{d(\alpha \cdot OD)}{dt} = \mu(\alpha \cdot OD) \quad (4)$$

Upon integration, Equation (4) becomes Equation (5), where OD0 is the initial optical density; ODt is the optical density at some time; t is some time, in hours; e, the base of the natural logarithm; and μ is the specific growth rate.

$$(\alpha \cdot OD_t) = (\alpha \cdot OD_0) e^{\mu t} \quad (5)$$

Upon solving for μ, the proportionality factor is reduced to 1 and Equation (5) becomes Equation (6), where ODt2 is the optical density at the time of recording, in cu; ODt1 is the initial optical density, in cu; t2 is the time of recording, in hours; and t1 is the initial time, in hours.

$$\mu = \frac{\ln(\alpha \cdot OD_{t_2} / \alpha \cdot OD_{t_1})}{(t_2 - t_1)} \quad (6)$$

2.5.3 Calculating generation/ doubling times

The generation time takes into account the doubling of microbial growth, meaning that if the cellular concentration at time 2 is divided by the cellular concentration at time 1 and the result is equal to 2, then the doubling time is equal to the difference in time (t2 – t1). Furthermore, this concept can be included into Equation (6) to determine the specific growth rate based upon the doubling time (td). Upon concept substitution, Equation (6) yields Equation (7). Therefore, once the specific growth rate has been approximated, Equation (7) can easily be used to determine the doubling time.

$$\mu = \frac{\ln(2)}{t_d} \quad (7)$$

2.5.4 Calculating the glucose Ks value

Monod (1949) developed a hyperbolic model (Equation 8) that is used to describe the relationship between the specific growth rates (μ) of an organism to various concentrations of a limiting substrate (s). This model is based upon two main microbial parameters: the maximum specific growth rate (μmax) and the constant of substrate saturation (Ks). The maximum specific growth rate can be biologically defined as the highest rate of growth that an organism can obtain for a particular substrate; whereas the substrate saturation constant represents the organism's affinity to the limiting substrate. The Ks value is defined as the value of the limiting substrate concentration that corresponds to the specific growth rate that is equal to one-half the maximum specific growth rate of the investigated organism.

$$\mu = \mu_{max} \frac{[s]}{K_s + [s]} \quad (8)$$

Since the Monod equation is extremely similar to the Michaelis-Menten equation for enzyme kinetics; equations that linearized the Michaelis-Menten model can also be applied to the Monod equation. These equations include the Lineweaver-Burk, Eadie-Hofstee and Hanes-Woolf. In this research, the Eadie-Hofstee equation is utilized because the resultant linearized equation specifically identifies the Ks value and the maximum specific growth rate.

To obtain the Eadie-Hofstee linearization of the Monod equation, the Monod equation (8) is inverted and multiplied by μmax (9) and afterwards rearranged for μmax (10). Finally, Equation 10 is then used to isolate μ (11). To create the Eadie-Hofstee plot, specific growth rates (μ) are graphed as a function of the respective growth rate divided by the associated substrate concentration (μ/[s]). As defined by Equation 11, the slope of the plot corresponds to the negative value of the saturation constant (-Ks) and the y intercept corresponds to the maximum specific growth rate (μmax).

$$\frac{\mu_{max}}{\mu} = \frac{K_s + [s]}{[s]} \quad (9)$$

$$\mu_{max} = \frac{\mu K_s}{[s]} + \mu \quad (10)$$

$$\mu = -K_s \frac{\mu}{[s]} + \mu_{max} \quad (11)$$

3. RESULTS

3.1 Specific Growth Rates and Generation Times

Growth data of P. luminescens from each glucose batch were used to determine growth rates and generation times (Table 1). To calculate the growth rates utilizing Equation (6), the two limit points (lower and upper) from the graphical method (Figure 1) were used and substituted into the equation. Generation times were also determined based upon the approximated growth rates from each method utilizing Equation (7).

3.2 Glucose Ks Determination of *P. luminescens*

Specific growth rates were plotted as a function of the respective glucose concentration to create a Monod curve (Figure 2). Upon examination of this Monod curve, the maximum specific growth rate appears to approach a value of 1.0

h-1. To determine the bacterium's affinity for glucose (Ks) and its maximum specific growth rate when cultured in glucose, the Eadie-Hofstee equation (Equation 11) is employed. Plotting specific growth rates as a function of the growth rate divided by it respective glucose concentration results in a line of best fit. The equation of the best fit line approximates the Ks value along with μmax. For *P. luminescens*, the Ks value for glucose is determined to be 1.95 mg/L with a maximum specific growth rate of 0.96 h-1.

4. DISCUSSION

Understanding the rates and patterns of microbial growth is essential to successfully culture cells to high densities. In theory, cultures that progress at their maximum specific growth rate under set conditions will reach higher cell densities in less time. Monod (1949) describes that specific growth rates will increase with increasing substrate concentrations until the maximum specific growth rate for the organism is reached for the particular substrate.

In reference to the data obtained from this study, the experimental glucose concentrations (1.8, 13.1, 18, 198 mg/L) produced variable specific growth rates. By means of the Monod's description of the maximum specific growth rate, we conclude that glucose concentrations exceeding 198 mg/L (1.1 mM) allows for *P. luminescens* to grow at its maximum growth rate (μmax). This result for the maximum specific growth rate does seem logical because the glucose concentration in the hemolymph of the insect host *Galleria mellonella* is ~1.1 mM (Wyatt and Kalf, 1957), which is represented by the 198 mg/L glucose batch. Therefore, pathogenicity and/or virulence may be related to the maximum rate of bacterial proliferation. Furthermore, Monod mentions the microbe's affinity to the substrate; otherwise known as the Ks or substrate saturation coefficient. Monod describes this coefficient as the substrate concentration at one-half the maximum specific growth rate. Based upon this study, we determined that the Ks value of *P. luminescens* for glucose is 1.95 mg/L. This value is within range with other glucose Ks values for enteric bacteria such as Escherichia coli (4 mg/L) and Klebsiella aerogenes (9 mg/L) (Nielsen, 2006).

Jeffke et al. (2000) performed a glucose study with *P. luminescens* to maximize bacterial density. This study included both batch and fed-batch cultures where they utilized an initial glucose concentration of 0.22% (2,200 mg/L) for each batch mode. From the results of our study, *P. luminescens* cultured in 2,200 mg/L glucose should be growing at its maximum specific growth rate. However, Jeffke does not report the growth rate for the batch culture. On the other hand, Jeffke reports that under fed-batch conditions they were able to maintain the growth rate of 0.05 h-1 by injecting glucose (0.2 – 0.4% concentrations) over a 50 hour period. This growth rate is extremely low when compared to the results of this study. Furthermore, the researchers utilized an enriched medium and to it the glucose was added. Through the utilization of this highly enriched medium, it is possible that the bacterial cells were stressed due to the high solute concentration and ultimately, negatively impacting the specific growth rate.

ACKNOWLEDGEMENTS

Partial financial support for this study was provided in part by the: North Carolina Biotechnology Center (grant number 2010-IDG-1008), UNC Pembroke Department of Chemistry & Physics and the Farm Bureau of Robeson County. We thank Dr. Prasanna B. Devarabhatta, Visiting Research Professor from the National Institute of Technology, Karnataka, Surathkal, India, for informative discussions on microbial kinetics. We also thank Mary Talkington and Joseph Workman for laboratory assistance.

Table 1 Comparison of graphical and calculated values of specific growth rates and doubling times

	Graphical		Calculated	
Glucose (mg/L)	Growth rate (h^{-1})	t_d (h)	Growth rate (h^{-1})	t_d (h)
0	0	0	0	0
1.8	0.46	1.52	0.46	1.52
13.1	0.78	0.89	0.78	0.89
18	0.91	0.76	0.92	0.75
198	0.95	0.73	0.95	0.73

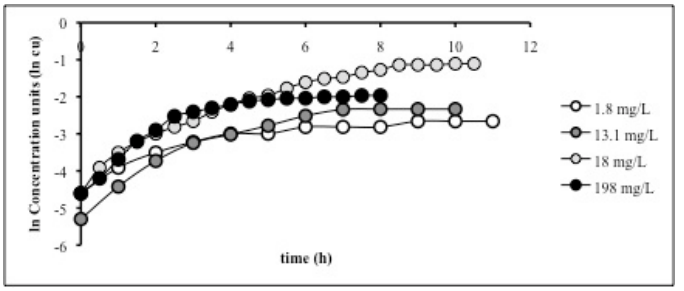


Figure 1: Natural log curves of *Photorhabdus luminescens* growth in batch cultures containing various concentrations of glucose. Specific growth rates (μ) for each batch are: 0.46 h-1 (1.8 mg/L); 0.78 h-1 (13.1 mg/L); 0.91 h-1 (18 mg/L); and 0.95 h-1 (198 mg/L).

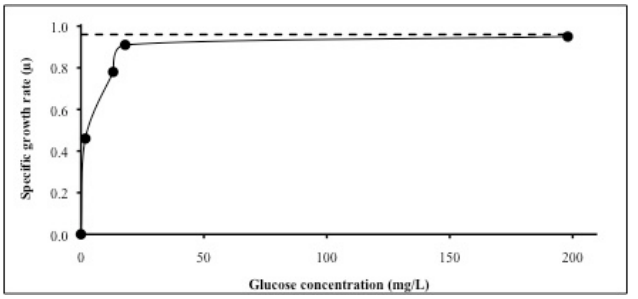


Figure 2: Monod plot depicting the hyperbolic relationship between glucose concentration and the specific growth rate of *Photorhabdus luminescens*. According to Monod, the maximum specific growth rate (dashed line) is the maximum rate that an organism can grow regardless of increasing the substrate concentration.

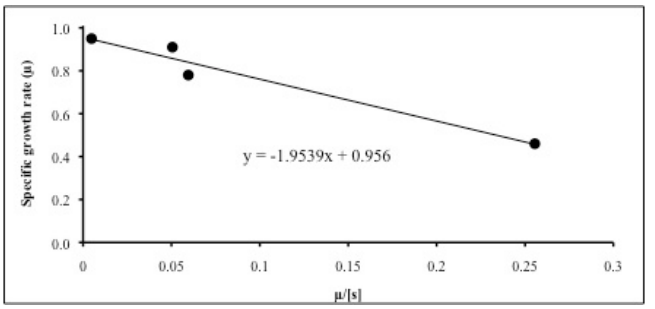


Figure 3: Eadie-Hofstee diagram used to determine the values of Ks and μmax in regards to glucose utilization of *Photorhabdus luminescens*. Utilization of the Eadie-Hofstee equation determined that the Ks of *P. luminescens* for glucose is 1.95 mg/L with a maximum specific growth rate (μmax) of 0.96 h-1.

REFERENCES

Bleakley B, Nealson KH (1988). Characterization of primary and secondary forms of *Xenorhabdus luminescens* strain Hm. FEMS Microbiol Eco 53: 241-250.

Boemare NE, Laumond C, Mauleon H (1996). The entomopathogenic nematode-bacterium complex: Biology, life cycle and vertebrate safety. Biocontrol Sci Technol 6: 333-345.

Ehlers R-U, Hokkanen HMT (1996). Insect biocontrol with non-endemic entomopathogenic nematodes (*Steinernema* and *Heterorhabditis spp.*): Conclusions and recommendations of a combined OECD and COST workup on scientific and regulatory policy issues. Biocontr Sci Technol 6: 295-302.

Ehlers R-U, Lunau S, Krasomil-Osterfeld K, Osterfeld KH (1998). Liquid culture of the entomopathogenic nematode-bacterium complex *Heterorhabditis megidis/Photorhabdus luminescens*. Biocontrol 43: 77-86.

Ehlers R-U, Stoessel S, Wyss U (1190). The influence of phase variants of *Xenorhabdus spp.* and *Escherichia coli* (Enterobacteriaceae) on the propagation of entomopathogenic nematodes of the genera *Steinernema* and. Rev Nématol 13: 417-424.

Inman F, Holmes L (2012). The effects of trehalose on the bioluminescence and pigmentation of the phase I variant of *Photorhabdus luminescens*. J Life Sci 6(2): 119-129.

Inman F, Singh S, Holmes L (2012). Mass production of the beneficial nematode *Heterorhabditis bacteriophora* and its bacterial symbiont *Photorhabdus luminescens*.

Indian J Microbiol Online First 2012 doi: 10.1007/s12088-012-0270-2

Jeffke T, Jende D, Matje C, Ehlers R-U, Berthe-Corti L (2000). Growth of *Photorhabdus luminescens* in batch and glucose fed-batch culture. Appl Microbiol Biotechnol 54: 326-330.

Kontnik R, Crawford JM, Clardy J (2010). Exploiting a global regulator for small molecule discovery in *Photorhabdus luminescens*. ACS Chem Biol 5(7): 659-665.

Monod J (1949). The growth of bacterial cultures. Annu. Rev. Microbiol. 3: 371-394.

Nealson KH, Schmidt TM, Bleakley B (1990). Physiology and Biochemistry of Xenorhabdus. In: Gaugler R, Kaya HK (Eds.) Entomopathogenic Nematodes in Biological Control (pp. 271-284). Boca Raton: CRC Press Inc.

Nielsen J (2006) Microbial Process Kinetics. In: Ratledge C, Kristiansen B (Eds.) Basic Biotechnology. 3rd Edition (pp. 155-180). Cambridge: Cambridge University Press.

Seydel P, Lieb M, Ehlers RU, Röck H (2000). Amino acid uptake of *Photorhabdus luminescens* in batch and fed-batch cultivation. Proceedings of the COST 819 Symposium and Working Group Meeting, NUI Maynooth, Ireland.

Stanbury PF, Whitaker A, Hall SJ (2003). Principles of Fermentation Technology. 2nd Edition Oxford: Butterworth Heinemann.

Strauch O, Ehlers R-U (1998). Food signal production of *Photorhabdus luminescens* inducing the recovery of entomopathogenic nematodes *Heterorhabditis spp*. in liquid culture. Appl Microbiol Biotechnol 50: 369-374.

Waterfield NR, Ciche T, Clarke D (2009). *Photorhabdus* and a host of hosts. Annu Rev Microbiol 63: 557-574.

Widdel F (2010). Theory and measurement of bacterial growth. (lecture) Retrieved from http://www.mpi-bremen.de/Binaries/Binary13037/Wachstumsversuch.pdf on 04 June 2012.

Wyatt GR, Kalf GF (1957). The chemistry of insect hemolymph. II. Trehalose and other carbohydrates. J Gen Physiol 40(6): 833-847.

Toxicity of Moist Snuff and Impact on Various Stages of Darkling Beetles (*Tenebrio molitor*)

Lisa Collins
with **Latisha Edwards**
Fayetteville State University
Faculty Mentor: Shirley Chao
Fayetteville State University

ABSTRACT

Moist snuff is a manufactured form of smokeless tobacco that, when consumed chronically, contributes to the leading cause of premature deaths in the world. Snuff contains several known toxins, such as nicotine, that have been proven to adversely affect organisms exposed to it through tobacco products. The objective of this study was to test whether moist snuff adversely affects darkling beetles by increasing mortality and hindering normal development of Tenebrio larvae. Results indicate that moist snuff did increase mortality, but also increased the developmental rate of survivors. In addition, a positive trend was observed in which moist snuff increased the amount of protein per insect without increasing average weight. Increases in protein amounts suggest possible compensatory responses to the toxic insult- grounds for further research.

According to the Centers for Disease Control and Prevention (2011), tobacco use is the leading cause of preventable death in the United States and a major cause of premature death worldwide. Tobacco is produced and manufactured into several products, which may be divided into the categories of smoking tobacco and smokeless tobacco. Smokeless tobacco comes in two forms: chew and snuff (Connelly, 2006), which contain more than 7,000 chemicals, 60 of which are known carcinogens (American Cancer Society, 2011). One of the most toxic ingredients found in tobacco products is nicotine. Nicotine is a powerful neurotoxic, psychoactive compound that occurs naturally in the leaves of tobacco plants, *Nicotiana tabacum* and *Nicotiana rustica* (Higa de Landoni, 1999). Chemically, nicotine is an alkaloid, or nitrogen containing substance (Naff, 2007), and functions as a natural insecticide. Variable amounts of nicotine are found in tobacco products, and depend on brand and product type. Studies show that nicotine in cigarettes account for approximately 1.21 mg to 2.16 mg per cigarette (Keithly, Cullen, & Land, 2004). For the purposes of this study, the focus is on moist snuff. Among the amalgam of chemicals, nicotine has been found in concentrations ranging from 0.59 percent up to 3.35 percent of snuff products per container (Tilashalski, Rodu, & Mayfield, 1994). Once nicotine is consumed in the form of moist snuff, it quickly enters the bloodstream through mucus membranes lining the mouth (LeVert, 2007), and acts on the brain as well as other organs within seconds (Naff, 2007). Tobacco products have been studied in great depths and are known to have adverse health effects on infants when consumed by expecting mothers. These effects include, but are not limited to, low birth weight and spontaneous abortion. In

addition, neurological effects are reported to be caused by tobacco use during pregnancy (Ernst et al., 2001). Though little research has been conducted on the direct effect of snuff use during pregnancy, there is evidence that its use may lead to premature delivery and preeclampsia (England et al., 2003). Several studies have determined the toxic effects of tobacco and nicotine on vertebrates such as humans, rats, and mice (Abreu-Villaca, Seidlera, Tatea, & Theodore, 2003); however, few experiments have been conducted to determine toxicity of tobacco products in insects such as mealworms.

The mealworm (*Tenebrio molitor*) has been a major pest of grain worldwide, costing high losses of stored grains, specifically in mills. As a result, pest management strategies have been studied to understand reproduction and development of this pest species (Taibi et al., 2003). In addition, the mealworm is an ideal animal model to understand animal development. Humans and mealworms may seem to have nothing in common, yet they share similar factors that control the nervous system and development in both (Brown, 2006).

The nervous system of an insect such as the mealworm is similar to that of a human because they share common neurotransmitters such as acetylcholine (Brown, May 2006). Acetylcholine plays a major role in the healthy functioning of the peripheral nervous system as well as muscle functioning in both humans and insects. The nicotine in tobacco products has the ability to mimic acetylcholine once it enters the body, which affects major systems of the body (LeVert, 2007). Due to similarities between the nervous systems of humans and insects, mealworms are excellent model organisms for toxicology research. In addition, mealworms undergo predictable patterns of development; therefore, they are ideal candidates for investigating factors that control animal development. Contrary to popular belief, the mealworm is not a worm, but the larval stage of the mealworm beetle, also called the darkling beetle of *Tenebrio molitor* species. The mealworm goes through four stages of development: (1) egg, (2) larva, (3) pupa, and (4) adult. The female darkling beetle lays hundreds of tiny, white, oval eggs which hatch into tiny mealworms (the larval stage). Each mealworm eats a tremendous amount and sheds its exoskeleton as it grows. It then enters its pupa stage. After pupating, a white adult darkling beetle emerges from the pupa; it soon turns brown, then almost black, completing the life cycle (Lawrence Hall of Science, July 2009). Since mealworms undergo complete metamorphosis during its lifecycle, the effects of a tobacco product such as snuff could be easily observed and analyzed (Gosselin & Fernandez, May 2011).

The purpose of our study is to test the effects of snuff exposure on darkling beetles, beginning in the larval stage, and to observe any adverse effects during development. Our study tested the following hypothesis: moist snuff adversely affects darkling beetles by increasing mortality and hindering normal development of *Tenebrio* larvae.

MATERIALS AND METHODS

The chemical used in the experiment was moist snuff, which is a finely ground form of smokeless tobacco. The brand was Longhorn Fine Cut Natural, manufactured at Pinkerton Tobacco Company LP, located in Owensboro, KY USA. This product contains at least 50% domestic tobacco. Kretschmer Original Toasted Wheat Germ processed in Manhattan, KS USA was used as the food source for the mealworms. A total of 30 mealworms (larval stage of darkling beetles) were obtained from PetSmart (Fayetteville, NC). Weighing of all materials was done

using a triple beam balance and organisms were tested and stored in 100mL plastic containers purchased from Thompson and Little Supply Store (Fayetteville, NC). All animals were stored at room temperature ranging from 20-25°C.

Procedure

The study was conducted over a five week period with treatments done one day a week on three occasions. We weighed each group of five mealworms, whose average weight was 0.5g, and 0.5g of moist snuff for a 1:1 ratio. For each snuff treatment, we added 0.5g snuff to 50-mL of water and incubated for 10 minutes. For each control, only 50mL of water was added to a cup. We then placed a group of mealworms in designated treatment cups and exposed for one minute, noting observations. The water was then drained, larvae dried on a paper towel, and transferred into their habitat which included wheat germ, a moist paper towel, and air holes in the lid. Mealworms were weighed each week before they were exposed to water or the snuff treatment for a total of three weeks. Once a larva entered the pupa stage, they were weighed, but not exposed to water or the snuff treatments. Upon entering the adult beetle stage, they were weighed and once again exposed. Development and body weight through various stages of the mealworm's lifecycle were documented each week (Figures 2 and 3). Mortality was noted and only survivors were maintained (Figure 1).

Protein Assay

Homogenization. Three adult beetles were obtained from the control group and the experimental group and placed into separate test tubes containing 1.0mL of sodium phosphate buffer (0.01M, pH 7.0). Each beetle was homogenized separately and centrifuged at 12000g for 3 minutes. The supernatant was removed from each sample and transferred into labeled tubes to be frozen until assayed for total protein using the Bradford method (Bradford, 1976).

Bradford Protein Assay. Bovine Serum Albumin (BSA) stock of 1mg/mL was prepared and used as the standard. Three milliliters of Bradford reagent (Thermo Fisher Scientific Inc., Waltham, MA) was added to each BSA standard (20, 40, 60, 80, 100µg). Absorbance was read for each BSA standard at 590nm, the peak wavelength determined. Each 15 µL sample of the darkling beetle supernatant with Bradford reagent was transferred to a cuvette and absorbance was read at 590nm.

RESULTS AND DISCUSSION

Our results were drawn by averaging data from three control groups and comparing the average of three experimental groups. We report observations on the following data: mortality after moist snuff exposure (Figure 1), total number of survivors at various stages of development (Figure 2), average weight of control and test groups (Figure 3), and average protein per beetle following treatments of moist snuff (Figure 4).

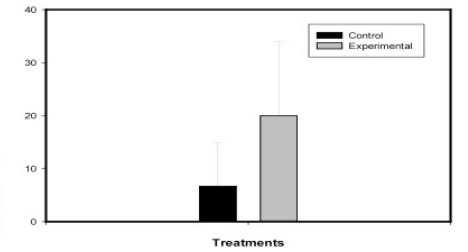


Figure 1. Mortality of Insects Following Treatments. Average percent mortality (±SE) after three weeks of treatments is shown. Control groups (n=15) were treated with water and Experimental groups (n=15) were treated with moist snuff.

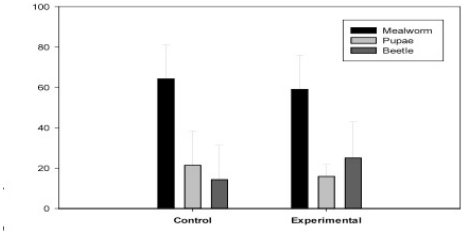


Figure 2. Effects of Moist Snuff on Rate of Development. The development of larva through its life cycle was observed and recorded following treatments of snuff (Experimental n=15) and water (Control n=15). The average percentage of each developmental stage is shown.

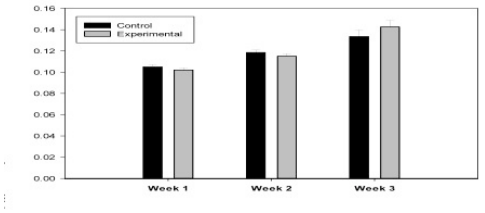


Figure 3. Average Weight of Insects Following Treatments. The weight of each group of insects was taken using an analytical scale before every treatment. The average weight (±SE) per insect was calculated for each treatment group each week for a total of three weeks. Week 1 Control: n=15; Week 1 Exp: n=15. Week 2 Control: n=14; Week 2 Exp: n =12. Week 3 Control: n=14; Week 3 Exp: n=12.

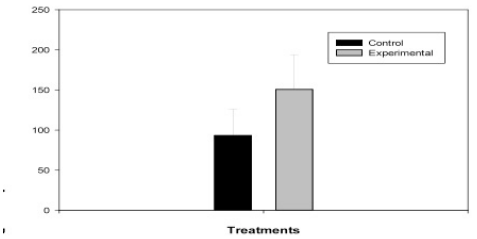


Figure 4. Average Protein per Adult Beetle (µg/15µL) Following Treatments with Snuff. The amount of protein of control beetles exposed to water (n=3) and experimental beetles exposed to moist snuff (n=3) was determined using the Bradford protein assay. The average amount of protein per insect was determined for the control and experimental group.

Mortality Following Moist Snuff Treatments

After the first week, one of fifteen insects in the control group and one of fifteen insects in the experimental group died. No other deaths were observed in control groups. However, more deaths were noted among the experimental group than the control group although significance was not reached (based on T-test analysis with significance set at *alpha* = .05).

We observed an overall 93% survival among the control group, and an 80% survival among the treatment group. The life stages appear to have progressed more quickly among the experimental group, although resulting in an equal number of adult beetles between the two groups at the end of the three weeks. All of the surviving darkling beetles in the experimental group were black, indicating that they had reached a later stage of development than the control group, which had one white beetle (newly emerged) and one brown beetle. In summary, after three weeks of exposure to moist snuff, 20% of experimental insects died. Control groups exposed to water alone only exhibited 7% mortality as shown in Figure 1.

Development of Larva

Differences in development were first observed two weeks after initial exposure. During week 1 of observations, of the initial 15 organisms, there were 14 survivors in each group. Of the 14 in the control group, 13 remained larval, and 1 had pupated. Of the 14 in the experimental group, 12 remained larval, and 2 had pupated. The following week (week 2), we observed 14 living organisms in the control group (7 larvae, and 7 pupae). There were only 12 survivors in the experimental group (6 larvae, 3 pupae, and 3 darkling beetles).

Week 2 marked the first observation of beetle development. The following week (week 3), our third and final observations were made. Our control group still included 14 living organisms (7 larvae, 1 pupa, and 6 beetles: 2 beige, 1 brown, and 3 black. These beetles were the first for the control group). The experimental group continued to have 12 living organisms (5 larvae, 1 pupa, and 6 darkling beetles: 1 dark brown, 5 black). It was noted that all of the beetles from the experimental group were very active. By the end of three weeks of treatment, the control group consisted of 64% larvae (mealworms), 21% pupae, and 14% adult beetles (Figure 2). The experimental group consisted of 59% larvae, 16% pupae, and 25% adult beetles. The beetles in the experimental group were darker than those in the control groups, indicating that the adults in the experimental group were older and had emerged before the control beetles. It was noted that the beige and brown beetles in the experimental group were also more active than the control beetles. While significance was not reached based on T-test analysis ($p>0.05$) of treatment groups by developmental stage, experiments should be repeated with more animals to confirm the trend observed.

Average Weight per Model Organism

Average weights of the control group in week one was 0.11g, and 0.10g for the experimental group (Figure 3). By week 2 (deaths taken into consideration) average weights were 0.12g for the control group, and 0.12g for the experimental group. By the third week, the control group weighed 0.13g, and the experimental group weighted 0.14g. No significant differences were observed for weights between the treatment groups based on T-test analysis ($p>0.05$).

Protein Assay

The Bradford protein assay was used to determine the concentration of protein in 6 adult darkling beetles; 3 protein samples from the control group and 3 protein samples from the experimental group. The control protein samples had an average of approximately 94µg of protein per 15µL of sample (Figure 4). The experimental samples had an average 151ug of protein per 15µL of sample. These results indicate that snuff may increase the amount of protein present in an organism. However, T-test analysis revealed that significant differences were not observed between control groups ($p>0.05$).

Because animals were exposed to water that contained moist snuff, it is unclear which chemical component of snuff was responsible for the results that we observed. Specific components should be isolated to determine which tobacco plant chemical could affect mortality and alter development as seen in this study.

Based on the results of our study, we must reject our original hypothesis. Although mortality was higher with insects exposed to the moist snuff, mortality was also observed with the control group. Further studies examining several concentrations of snuff (or nicotine) should be explored to determine LC50 (lethal concentration to produce 50% mortality), a more statistically consistent number and useful for comparisons.

While we cannot conclude that snuff had a significant impact on overall developmental rate of beetle larvae, specific developmental stages should be explored further, especially the development from pupae to adults. Our findings appear to indicate that snuff may increase the rate of development to the adult stage. More animals need to be tested with a more relevant exposure concentration however to reach statistical significance.

Our results may also indicate that snuff caused the organisms to be more active. It is unclear if nicotine was the direct cause

of any of these effects. However, our protein data suggest that moist snuff might have induced protein synthesis in insects as a possible defense mechanism as shown in many animals exposed to a particular toxin. While we cannot conclude that snuff significantly impacted overall weight and protein in these animals, the overall weight was measured for all developmental stages rather than each developmental stage. Because the protein data reflect only adult protein levels, it remains to be seen whether snuff actually increased the overall weight of the adults. Further studies should be conducted to clarify the discrepancies in weight and overall protein. In addition, further research should be conducted to understand the impact of nicotine (at low concentrations) on the growth rate of insects. Such research would benefit the application of pest management strategies, particularly those that involve insecticides that inhibit acetylcholinesterases (enzymes that degrade the neurotransmitter, acetylcholine). Because nicotine mimics the actions of acetylcholine, such research would prove to be useful in developing pest management strategies.

ACKNOWLEDGEMENTS

A special thank you to Hamzah Kharabsheh for technical assistance with exposures and protein assays.

REFERENCES

Abreu-Villaca, Y., Seidlera, F.J., Tatea, C.A., & Theodore, S. (2003). Nicotine is a neurotoxin in the adolescent brain: critical periods, patterns of exposure, regional selectivity, and dose thresholds for macromolecular alterations. Brain Research, 114-128.

American Cancer Society. (2011, November 11). What is in tobacco? Retrieved April 17, 2012, from American Cancer Society: http://www.cancer.org/Cancer/CancerCauses/TobaccoCancer/CigaretteSmoking/cigarette-smoking-tobacco.

Bradford, D, M. M. (1976). A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding. Analytical Biochemistry, 722, 248-254.

Brown, A.E. (May 2006). Mode of Action of Insecticides and Related Pest Control Chemicals for Production Agriculture, Ornamentals, and Turf. College Park, MD: University of Maryland.

Centers for Disease Control. (2011, March 8). Retrieved April 16, 2012, from Centers for Disease Control and Prevention: http://www.cdc.gov/tobacco/data_statistics/facts_sheets/tobacco_industry/index.htm.

Connelly, E.R. (2006). Nicotine = Busted. Berkeley Heights, NJ: Enslow Publishers, Inc.

Cornelius, M.D., & Day, N.L. (2000). The Effects of Tobacco Use During And After Pregnancy on Exposed Children. Alcohol Research & Health, 242-249.

England, Lucinda J., M.D., Levine, Richard J., M.D., Mills, James L., M.D., Klebanoff, Mark A., M.D., Yu, Kai F., PH.D. & Cnattingius, Sven, M.D., PH.D. (2003, October). Adverse Pregnancy Outcome of Snuff Users. American Journal of Obstetrics and Gynecology, Vol. 189, Issue 4, pp. 939-943. Retrieved April 24, 2012 from http://www.sciencedirect.com/science/article/pii/S0002937803006616.

Ernst, Monique, M.D., PH.D., Moolchan, Eric T., M.D., & Robinson, Miqun L., M.D., PH.D. (2001, January 17). Behavioral and Neural Consequences of Parental Exposure to Nicotine. Journal of the American Academy of Child & Adolescent Psychiatry, Vol. 40, Issue 6, pp. 630-641. Retrieved April 24, 2012 from http://www.sciencedirect.com/science/article/pii/S0890856709604664.

Gosselin, M., & Fernandez, M.D. (May 2011). Entomotoxicology, experimental set-up and interpretation for forensic toxicologists. Forensic Science International, Vol. 208 Issue 1-2, p1-9, 9p.

Higa de Landoni, Julia (1991) Nicotine. International Programme on Chemical Safety (IPCS) INCHEM. Retrieved April 16, 2012 from http://www.inchem.org/documents/pims/chemical/nicotine.htm.

Keithly, L.PhD., Cullen, D. MA, Land, T. Ph.D. (2004). Change in Nicotine Yields 1998-2004. The MassachusettsTobacco Control Program, Massachusetts Department of Public Health. Retrieved August 27, 2012, from http://www.fda.gov/downloads/AdvisoryCommittees/CommitteesMeetingMaterials/TobaccoProductsScientificAdvisoryCommittee/UCM244891.pdf.

Lawrence Hall of Science. (2009, July 31). Mealworms and Darkling Beetles (*Tenebrio* beetle). Full Option Science System (FOSS). Retrieved June 11, 2012, from Lawrence Hall of Science: http://lhsfoss.org/fossweb/teachers/materials/plantanimal/tenebriobeetles.html.

LeVert, S. (2007). Drug the Facts about Nicotine. Tarrytown, NY: Mashall Cavendish Benchmark.

Naff, C.F. (2007). Nicotine and Tobacco. San Diego: Reference Point Press Inc.

Taibi, F., Smagghe, G., Amrani, L., Soltani-Mazouni, N. (2003). Effect of ecdysone agonist RH-0345 on reproduction of mealworm, *Tenebrio molitor.* Comparative Biochemistry and Physiology Part C 135: 257-267.

Tilashalski, K., Rodu, B., & Mayfield C. (May 1994). Assessing the nicotine content of smokeless tobacco products. The Journal of the American Dental Association. Retrieved August 27, 2012, from http://jada.ada.org/gca?submit=Go&gca=jada%3B125%2F5%2F590&allch=.

The Effects of Ocean Acidification on the Development of *Lytechinus variegatus* (Green Sea Urchins)

Breanna C. DeGroot
University of North Carolina Wilmington
Faculty Mentor: Heather Koopman
University of North Carolina Wilmington

ABSTRACT

The purpose of this experiment was to study the effects of ocean acidification on early spicule formation and development in Lytechinus variegatus (green sea urchins). After induced spawning of adult green sea urchins occurred the larvae were placed in a control (8.1pH) and experimental (7.6 pH) tank of equivalent salinity, dissolved oxygen (DO), temperature, volume, and sea water. Soon after fertilization was confirmed ten randomly selected larvae from each tank were observed and recorded using a compound microscope. Our results showed similar rates of growth in the early stages of development (Fertilization - hour 6) with significant differences in later development (hours 12 - 22). Overall, this experiment was successful in observing the effects of ocean acidification in developing Lyechinus variegatus sea urchins; however, more experiments should be conducted to verify the results and reduce the extinction rate of the acidic environment.

Marine environments can possess a variety of stressors to both adult and particularly, larval organisms. A major stressor marine organisms often encounter is acidic waters formed by a process known as ocean acidification (1). Ocean acidification is a consequence of elevated levels of dissolved carbon dioxide in the water which then forms carbonic acid and further dissociates into bicarbonate and carbonate ions; releasing H+ ions and ultimately lowering the pH (2). The present level of atmospheric carbon dioxide (approximately 300-380 ppm) is predicted to increase dramatically to levels between 450 - 1,000 ppm by 2100 (3). This increase can be attributed to human fossil fuel combustion and deforestation rates which have increased by an order of magnitude faster than in the last few thousand years (1).

Calcifying marine invertebrates require carbonate ions for the production of their skeletons, but with an increase in acidification the carbonate ions become less available, reducing not only the size but also strength of the organism's skeleton (4). If the ocean remains at a constant salinity, the calcium concentration will also remain nearly constant due to the direct relationship between calcium and salinity; and as such the calcification process is primarily dependent on the level and availability of carbonate ions (4).

The survival of most marine species depends on the ability of the species larvae to locate a compatible settlement site with suitable water chemistry (5). In echinoderms, another important factor in species survival is production of appropriate egg size; however, ocean acidification can cause egg size to decrease to an un-survivable state (6). Specifically, direct developing sea urchins, which do not feed and begin transformation into the adult form after a single day, are greatly

affected (7). After insemination, sea urchin zygotes typically lower their pH. However, molecular carbon dioxide caused by acidification easily diffuses into the gametes additionally decreasing the intracellular pH and preventing subsequent development (8). During the sea urchins planktonic stage and early development they spend an extended period of their growth in the water column where the water chemistry and temperature of the water have major impacts on development (9). Echinoderms are highly susceptible to ocean acidification because they lack both an impermeable barrier between the outside seawater and their internal cavity and they also use active transport mechanisms meaning they have little mechanisms for buffering changes in the acid-base balance of their fluids (10).

PROCEDURE

This experiment was broken into a pretrial stage and experimental stage.

Pre-trial

One twenty gallon tank was used to house the adult *Lytechinus varigeatus* sea urchins; it was equipped with an Aqueon QuietFlow 20 filter, 19 ± 1 gallon of 1 micron filtered sea water, and a heater. Two ten gallon tanks equipped with an Aqua Tech 10-20 Power filter and filled 9 ± 1 gallon of 1 micron filtered sea water were also set up as the control and experimental tanks. All tanks were monitored for a one week acclimation period. Water quality parameters included measuring: dissolved oxygen (DO), salinity, temperature, and pH with an YSI model 556 MPS portable meter. The YSI meter was calibrated prior to the start of the trial and calibrated for DO before every use. DO was maintained at 85% ± 3%, salinity 32 ppt ± 1.75 ppt, and temperature were also maintained at 22oC ± 2o C. A carbon dioxide tank and pH meter were attached to the experimental tank which was calibrated to maintain a pH of 7.6 ± .02. Both the adult sea urchin tank (20 gallon tank) and the control tank were maintained at a pH of 8.1 ± 0.2. During the course of the experiment adult sea urchins were each individually fed once daily.

Experimental trial

Six *Lytechinus varigeatus* sea urchins were randomly selected and, using a syringe, each sea urchin was injected with 1.5 mL of a 0.05M solution of potassium chloride into the central cavity to induce spawning. After injection the sea urchins were swirled and inverted over a cup for a maximum of 15 minutes or until gametes were released. Female gametes, which appeared slightly yellow in color, were added to 25 mL of 1 micron filtered sea water and washed by allowing the eggs to sink to the bottom of the cup. After the eggs sank the water was decanted and the washing process was repeated several times to reduce the eggs' membrane barrier. Male gametes, which appeared white in color, were not washed. To confirm gamete sex each cup's contents were observed under a microscope. After washing the eggs, the male and female gametes were combined to induce fertilization. Once fertilization was confirmed under a compound microscope the contents of the cup were evenly divided into the control and experimental tank. Sea urchin development was observed and documented at specific intervals for three days: 1 hour after fertilization, 3 hours after fertilization, 6 hours after fertilization, 12 hours after fertilization, 22 hours after fertilization, 24 hours after fertilization and every 24 hours thereafter until the completion of the experiment. Before each observation water quality was tested and recorded. To observe larvae, a pipette was used to extract each larva from the bottom of each tank. The first 10 randomly selected larvae from each pH treatment were observed and each individual's stage

of development was documented. After observation, larvae were disposed of to avoid the possibility of counting the same larva twice in the experiment. Results of the acid treatment were then compared to a normal pH treatment which should have had a normal triangular shaped body with two arms and minimal asymmetry.

RESULTS AND DISCUSSION

Echinoderms are highly susceptible to ocean acidification because they lack an impermeable barrier between the outside seawater and their internal cavity. Further, they use active transport mechanisms, meaning they have little ability to buffer changes in the acid-base balance of their fluids (10). Because of this, I expected development to be slowed in the experimental tank when compared to the control tank. The developmental stages one hour after fertilization showed there was no difference between the acid and control pH levels of development (Figure 1) and as such these data were not significant (chi square for 1 and 3 hours, $p > .05$). As stated in previous studies, early larvae development (development from fertilization to roughly ten hours after fertilization) is rarely significantly affected by increasing pH levels (6). Results of the experiment showed a slower pace of development in the acidic treatment with fewer noticeable differences at the early stages of development (Figure 2). A two-way chi square test used to analyze these data was not significant ($p > .05$). After six hours in the pH treatment the larvae in the acid treatment started to show signs of a slower pace of development (Figure 3); however, results of the results were not significant ($p > .05$). Fisher's exact test was used for the rest of the calculations because the data did not meet the assumptions of the two-way chi square test (zero value or lack of observation for a specific developmental stage at that time).

These non-significant results, although not predicted, can be understood by considering echinoderms' ability to buffer the fluids in and around their internal cavity which delayed the effects of ocean acidification (10). The increase in the amount of time spent in the acid treatment started to have more significant negative effects on the rate of development as time increased ($p < .05$; see Figures 4 and 5 and Table 2). This positive correlation between decreased pH level and pace of development is thought to be a result of the length of time spent in the treatment along with the complexity of development. As the zygotes spent more time in the acidic treatment, the availability of calcium ions necessary to complete their calcium bicarbonate skeleton diminished, decreasing the rate of development.

At 22 hours after fertilization mass mortality occurred in the acidic pH treatment [see Figure 5; results confirmed by Fisher's exact test $p < .05$]. This was hypothesized to occur due to the low levels of calcium in the water which prevented subsequent development and further use of calcium in the water. Because the experimental pH value was at an extreme level, once the availability of calcium decreased it was possible for the acidic water to dissolve the calcium already formed around the zygote, reducing and eventually removing the protective barrier which resulted in mortality for these sea urchins.

Overall this experiment was successful in determining how sea urchins may be affected by ocean acidification; however, more experiments are necessary to determine more possible causes for mass mortality at a pH level of 7.6. This study also shows, as others have previously, that further research is necessary when considering the overall effects of ocean acidification on echinoderms. This can be

achieved in many ways, including looking at the specific calcium concentration available in the water as sea urchins develop to determine the potential for those organisms to survive and by examining sea urchins variability and adaptability potential. Other studies which look at different classes of echinoderms, species that display varying habitat, or alternative life cycles will help further understand the effects of ocean acidification on a deeper level. However, based on this study, it is now clear that ocean acidification will have a negative effect on the development of *Lytechinus variegatus*.

ACKNOWLEDGEMENTS

The author would like to thank Janie McAuliffe, Jeremy Burnett, and Ronald Moore for their expertise and funding.

Figures

The pH effects on the development of Green Sea Urchin embryos. Figures below are separated by the amount of hours after fertilization development was observed for each pH treatment. Each figure displays the calculated standard deviation for each pH treatment at each hour of development.

Figure 1.

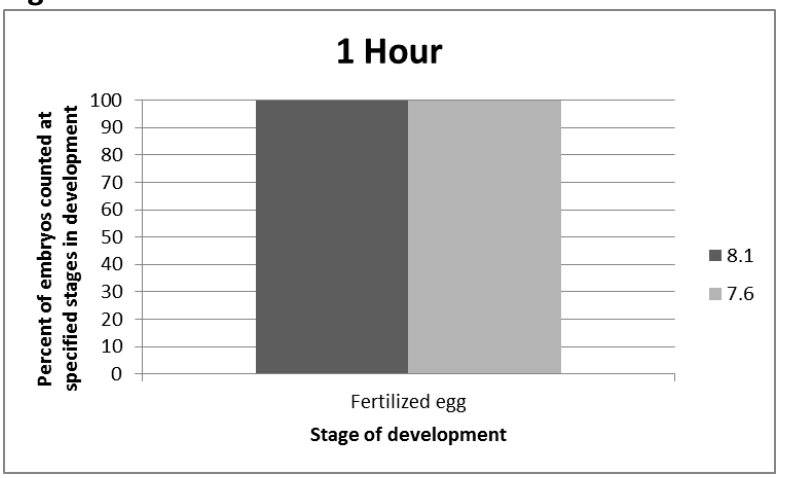


Figure 2.

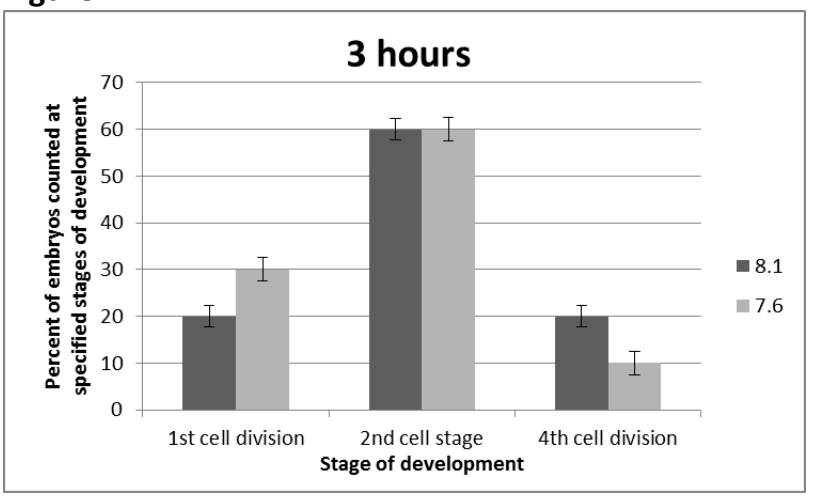


Figure 3.

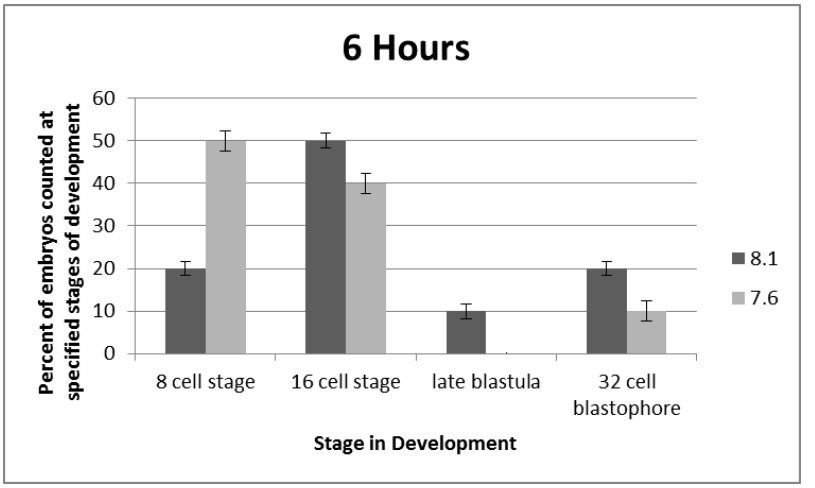


Figure 4.

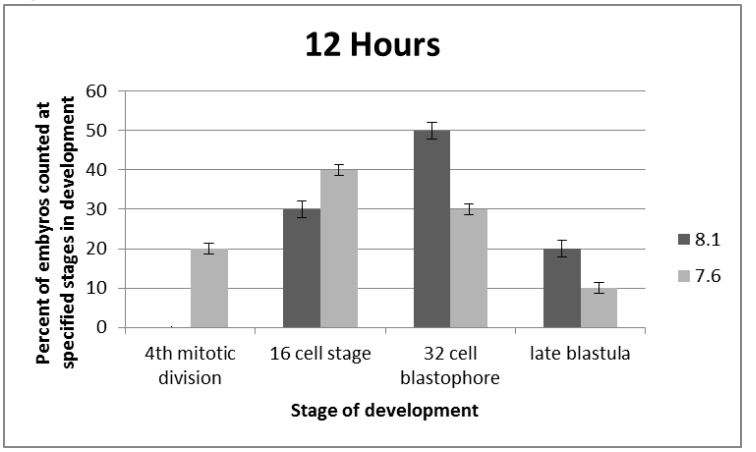
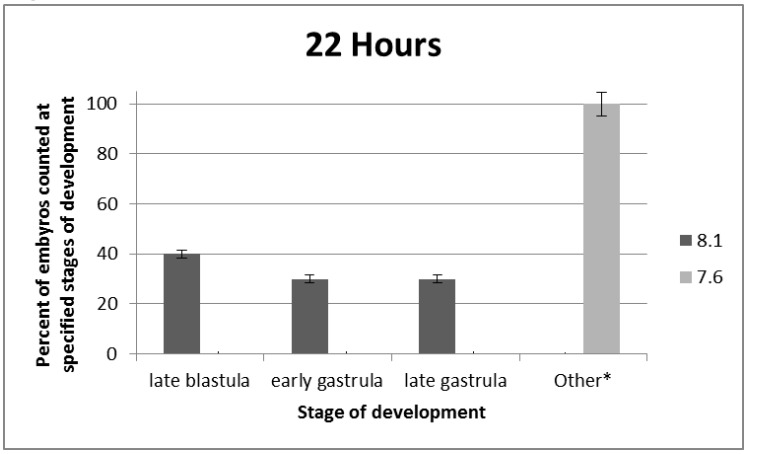


Figure 5.



***p < .05;** *Other represents the amount of embryos which disintegrated at this hour of development.

REFERENCES

1. Doney Scott C., Victoria J. Fabry and Richard A. Feely. Ocean Acidification: The Other CO(2) Problem. Annual Review Of Marine Sciencebook Series: Annual Review Of Marine Science 1.(2009): 169-192.

2. Clark, Dana, Miles Lamare, and Mike Barker. Response of Sea Urchin Pluteus Larvae (Echinodermata: Echinoidea) to Reduced Seawater PH: A Comparison Among a Tropical, Temperate, and a Polar Species. Marine Biology 156.6 (2009): 1125-1137.

3. Byrne, Maria. Temperature, but Not Ph, Compromises Sea Urchin Fertilization and EarlyDevelopment Under Near-Future Climate Change Scenarios. Proceedings Of The Royal Society B: Biological Sciences 276.1663 (2009): 1883-1888.

4. Gazeau, Frederic, Christophe Quiblier, Jereon M. Jansen, Jean-Pierre Gattuso, Jack J. Middelburg, and Carlo H.R. Heip. Impact of Elevated CO2 on Shellfish Calcification. Geophysical Research Letter. 34.L07603 (2007).

5. Munday, Philip L, Danielle L. Dixson, Jennifer M. Donelson, Geoffrey P. Jones, Morgan S. Pratchett, Galina V. Devitsina, Kjell B. Døving and David M. Karl. Ocean Acidification Impairs Olfactory Discrimination and Homing Ability of a Marine Fish. Proceedings Of The National Academy Of Sciences Of The United States Of America 106.6 (2009).

6. Alcorn, Nicholas J., and Jonathan D. Allen. How Do Changes in Parental Investment Influence Development in Echinoid Echinoderms? Evolution & Development 11.6 (2009): 719-727.

7. Raff, Rudolf A., et al. Axial Patterning of the Pentaradial Adult Echinoderm Body Plan.Development Genes & Evolution 219.2 (2009): 89-101.

8. Kurihara, Haruko. Effects of CO2-driven ocean acidification on the early developmental stages of invertebrates. Marine Ecology Progress Series 373 (2008): 275-284.

9. Sheppard, Hannah Brennand, Natalie Soars, Symon A. Dworjanyn, Andrew R. Davis, and Maria Byrne. Impact of Ocean Warming and Ocean Acidification on Larval Development and Calcification in the Sea Urchin Tripneustes Gratilla. PLOS ONE. 5.6 (2010)

10. Nimmo, Malcolm, et al. Impacts of Ocean Acidification and Burrowing Urchins on Within Sediment pH Profiles and Subtidal Nematode Communities. Journal Of Experimental Marine Biology & Ecology 365.1 (2008): 46-52.

Sequence and Structural Analogies between Glyceraldehyde-3-Phosphate Dehydrogenase of *Homo sapiens* and the CysP Periplasmic Binding Protein from *Escherichia coli*

Garreesa S. Henry
Livingstone College
Faculty Mentor: Rufus M. Williamson
Livingstone College

ABSTRACT
Substrate-binding proteins are components of ATP-binding cassette transporters which capture their substrates in the periplasm of bacteria. These proteins subsequently deliver their bound ligands to membrane components of the transporters. Bacterial periplasmic substrate-binding proteins are characterized by a Venus flytrap motif which is involved in the ability of the protein to capture their cognate substrates. Proteins with similarities to bacterial periplasmic binding proteins and having domains that resembles a Venus Flytrap have been also identified in eukaryotic cells. To further characterize eukaryotic proteins which resemble bacterial periplasmic binding proteins, bioinformatics techniques and procedures were used to survey of the human genome. Results of amino acid sequence analyses reveal that glyceraldehyde-3-phosphate dehydrogenase displays a 49.6% amino acid sequence similarity to the CysP periplasmic binding protein, for sulfate, in Escherichia coli. Reliability estimates indicate that the likelihood that the two proteins belong to the same family of the proteins was approximately 99.6%. Secondary structural comparisons and homology modeling studies suggest that glyceraldehyde-3-phosphate dehydrogenase may contain a domain which resembles the Venus flytrap motif that is common to periplasmic binding proteins. The results are interpreted to suggest that the two proteins are analogous.

ATP-binding cassette transporters are members of a protein superfamily that is one of the largest and most ancient families with representatives in all extant phyla from prokaryotes to humans. These transporters are composed of complexes that consist of two alpha-helical transmembrane domains, which form a translocation pathway, and two cytoplasmic domains, which power the transport reaction through binding and hydrolysis of adenosine triphosphate (ATP). The energy derived from hydrolysis is associated with the translocation of various substrates across membranes[1].

Periplasmic substrate-binding proteins are components of ATP-binding cassette transporters. These proteins bind their substrates, in the periplasm, selectively and with high affinity, and deliver bound ligands to the extracellular gate of the transmembrane domains within the transport complex. In bacteria, periplasmic binding proteins also play roles in chemotaxis[2], and intercellular communication[3] processes.

X-ray crystallographic studies have shown that periplasmic binding proteins consist of two large lobes that close around the bound ligand, resembling a Venus Flytrap[4]. The Venus Flytrap domain has been proposed to be encoded in an 8-residue motif[5]. Intriguingly, proteins with similarities to periplasmic binding proteins and having domains that resembles a Venus Flytrap have been identified in eukaryotic cells[1].

The metabotropic receptor extracellular domain is a member of a family of structural domains linked to a variety of receptor types, including ionotropic glutamate receptors[6]. Both amino acid sequence and structural modeling studies has revealed that the metabotropic receptor extracellular domain is similar to bacterial periplasmic amino acid binding proteins[7].

DING proteins, named for the presence of the amino acids, in their single letter abbreviation, DINGGGN, and located in the carboxyl termini of these proteins resemble periplasmic binding proteins. DING proteins are ubiquitous in living organisms[8]. Many DING proteins have been isolated in eukaryotes. They have been associated with very diverse biological activities, often in the context of possible signaling roles and are associated with both normal and pathological functions in mammals[8, 9]. Their phosphate-binding function suggests a role in biomineralization, and the ability to bind other ligands may be related to signal transduction in eukaryotes[9]. Additionally, a new family of receptor tyrosine kinases with a Venus Flytrap binding domain in insects and other invertebrates has been identified[10]. The Venus Flytrap domain is an ancient protein module present in multiple proteins and may represent a promising area for drug discovery research owing to the ability of proteins with the domain to capture molecules. It has been postulated that, in the process of evolution, genes for proteins containing the Venus Flytrap motif may have fused with genes with other proteins[8].

To further characterize proteins which resemble bacterial periplasmic binding proteins in eukaryotes, a survey of proteins in the human genome was conducted. In this study, bioinformatics tools and procedures were used to identify glyceraldehyde-3-phosphate dehydrogenase (EC 1.2.1.12) as a protein which resembles a periplasmic sulfate-binding protein in bacteria. Identification of additional proteins in eukaryotes with the Venus Flytrap domain could facilitate research in drug discovery, as well as, understanding of the molecular evolution of proteins.

METHODS

Search Strategy. A set of 70 amino acid sequences for bacterial periplasmic binding proteins was extracted from the Kyoto Genes and Genome database (KEGG)[11]. The KEGG database is a repository of information on the current knowledge of the genetics, biochemistry, and molecular biology of individual genes[11]. The set of amino acid sequences were compared and grouped by similarity into 7 distinct clusters. Members of a cluster frequently have shared substrate specificity (i.e., carbohydrates, amino acids, and metals). Consensus sequences were determined for each group by the methods of Brown, and Lai[12] (data not shown). A consensus sequence is the representation of a sequence alignment in terms of the most frequently occurring amino acid residues found at each position. Conserved amino acid substitutions which are defined as replacement of an amino acid residue with another one with similar properties were considered. Also, semi-conserved substitution amino acid, defined as replacement of an amino acid residue with another that has similar steric

conformation, but does not share chemical properties were also considered. Amino acid replacement groups for conservative replacements, in one-letter code are STA, NEQK, NHQK, NDEQ, QHRK, MILV, MILF, HY, and FYW. Semi-conservative amino acid replacements are CSA, ATV, SAG, STNK, STPA, SGND, SNDEQK, NDEQHK, NEQHRK, FVLIM, and HFY. The one-letter code for amino acids is a useful way to display to represent amino acids.

Consensus sequences, along with, representative amino acid sequences for each group, were used as query sequences to search against *Homo sapiens* proteins data located in GenBank[13] and SwissProt databases[14]. GenBank and SwissProt are comprehensive databases that contain publicly available nucleotide and/or protein sequences, as well as, functional information. We reasoned that it was unlikely to identify eukaryotic proteins that were homologous (i.e. proteins which share similar functions and common evolutionary ancestry) to bacterial periplasmic binding proteins. This is in part due to the evolutionary distance between bacteria and *Homo sapiens*, and the lack of the equivalent of a periplasmic space in eukaryotes. Thus, a search for analogous proteins was conducted. Analogous proteins share similar functions, but lack a common ancestral origin. Two approaches were used to identify putative similarities in the genome of *Homo sapien*s. Position-Specific Iterative Basic Local Alignment Searches (PSI-BLAST) were conducted to detect distant relationships between proteins[15]. In addition, to improve our ability to detect distantly related proteins that may not be identified by the PSI-BLAST algorithm, a second strategy was employed. The approach neglects the order of amino acid residues in a sequence, and uses properties of constituent amino acid instead to query the SwissProt database[16]. In this approach, a total of 144 individual characteristics for a given amino acid were used which included properties such as molecular weight, content of bulky residues, content of small residues, average hydrophobicity, and average charge.

Protein Structural Studies. Consensus secondary structure predictions, derived from several prediction algorithms, were performed using the Network Protein Sequence Analysis Tool[17]. Secondary structural elements are indicated by solid color coils (α-helices), coils (random coils) and rods (extended strand) along the primary sequence, and where (---) indicate sequence interruptions.

Three dimensional homology models of protein structures were constructed using the Swiss Model software[18, 19] with templates obtained from Protein Databank[20]. Homology modeling relies on the identification of protein structures likely to resemble the structure of a protein in question, and on the production of an alignment that maps residues in the protein of known three-dimensional structure to residues in protein in question.

RESULTS AND DISCUSSION

Relationships between proteins may be considered into two different ways. Proteins may display the same activity and show sequence similarity suggesting a common ancestral origin. Inferential statistics are frequently used to evaluate their relatedness. When any two proteins sequences or domains within proteins display statistically significant similarities, the proteins are considered as being homologous.

Proteins may also display the same activity but lack sufficient similarity to imply common origin. Such proteins are said to have analogous activity. The implication is that analogous proteins followed

evolutionary pathways from different origins to converge upon the same activity. Thus, analogous proteins are considered a product of convergent evolution. That is, analogous proteins have homologous activity but heterologous origins. Evidence that two proteins are related by analogy frequently involves comparisons of protein secondary and tertiary structure, as well as, comparison of primary sequences structure, which may not show statistically insignificant relationships. In this study, evidence of possible protein analogies was considered.

Analysis of the human genome revealed that the enzyme glyceraldehyde-3-phosphate dehydrogenase (EC 1.2.1.12) resembles the CysP periplasmic sulfate-binding protein in bacteria. The GAPDH protein for gyceraldehyde-3-phosphate dehydrogenase is 335 residues in length. GAPDH is a key enzyme in glycolysis that catalyzes the first step of the pathway by converting D-glyceraldehyde 3-phosphate (G3P) into 3-phospho-D-glyceroyl phosphate[21]. The enzyme also participates in nuclear events[22].

Glyceraldehyde-3-phosphate dehydrogenase from *Homo sapiens* was found to display 49.6% similarity to CysP of *Escherichia coli* with 13% identical residues and where 36% constituted conservative or semiconservative sequence matches. To achieve optimal similarity between the proteins, 7 small gaps were introduced in the alignment (see Appendix). A reliability estimate, derived from a set of 1300 sequences, and belonging to 58 proteins produced a probability of 99.6% for the likelihood that the two proteins belongs to the same family of the proteins[16]. The amino acid sequences for glyceraldehyde-3-phosphate dehydrogenases are strongly conserved across all phyla[23]. Thus, results found in *Homo sapiens* may extend to other species.

Secondary structural comparisons indicate the alpha helical characteristics of the CysP protein is 41.4% and the alpha helical characteristics of glyceraldehyde-3-phosphate dehydrogenase is lower than that observed in CysP protein consisting of 21.8% of the protein. The enzyme has a higher extended strand potential comprising 26.8% of the protein as compared to CysP with 13.9%. Both proteins have the same random coli potential. In GAPDH, the random coli potential was 48.9% as compared to CysP with 43.5%. The overall distribution of structural characteristics was found to be similar through much of the two proteins. Residues 110-240 of GAPDH are highly similar to residues 100-230 of the periplasmic binding protein (Figure 1). Residues 240-259 of the dehydrogenase enzyme have the same distribution coil and α-helical characteristics as 240-260 of the periplasmic binding protein. Both proteins lack regions predicted to contain beta-pleated sheet structures.

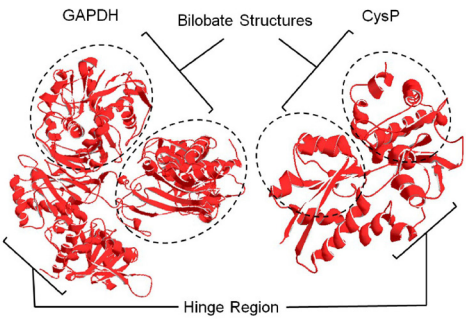


Figure 1. Homology models of glyceraldehyde-3-phosphate dehydrogenase (GAPDH) and CysP periplasmic binding proteins. The Venus Flytrap motif is indicated and the proposed motif in GAPDH is shown.

To support the observations derived from predictions of secondary structure, atomic-resolution models of the proteins were determined by homology modeling studies. It has been shown that protein structures are more conserved than protein sequences amongst homologues, but

sequences falling below a 20% sequence identity can have very different structure [24].

Homology models of the three dimensional structure of both proteins has been determined where the structures of 1sbp and 1u8f (Protein Data Bank accession numbers) [20] were used as templates for CysP and GAPDH, respectively. As shown in Figure 1, the structure of CysP has a bilobate region and a hinge region that is characters of all proteins that adapts to the Venus Flytrap motif. GAPDH also appears to have a structure similar to the general structure of a Venus Flytrap motif. It is suggested that, owing to the bilobate region and a hinge region, GAPDH has a fold structure characteristic of periplasmic binding proteins.

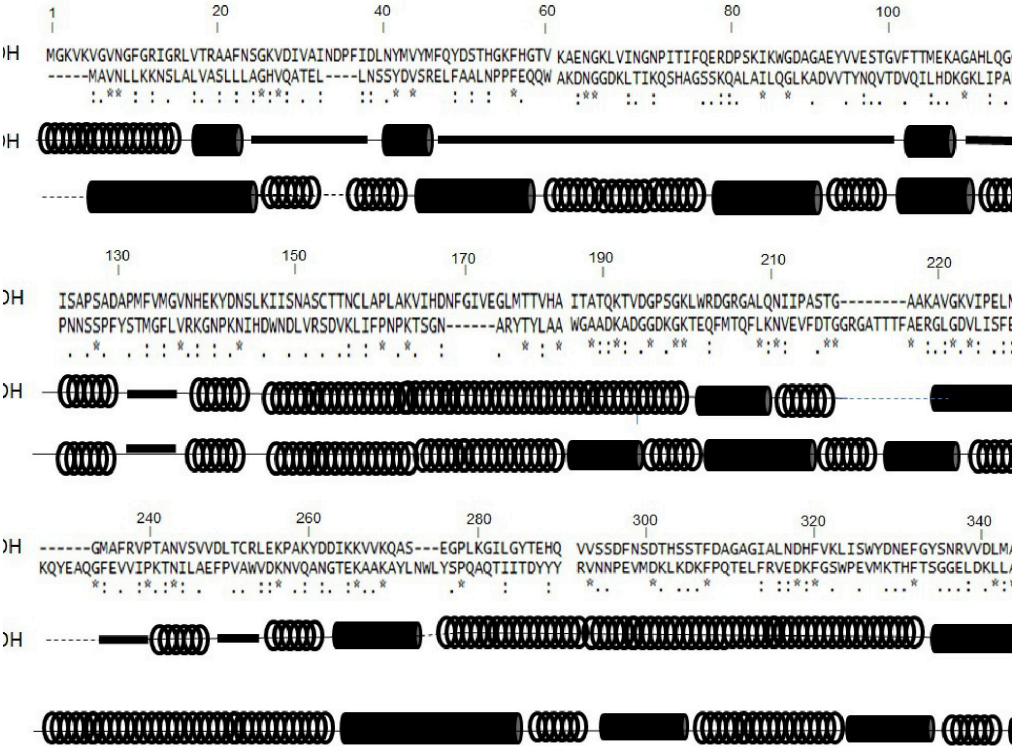
The results of this study support the idea that sequence and structural analogies exist between glyceraldehyde-3-phosphate dehydrogenase and periplasmic binding proteins. A Venus Flytrap motif in the structure of glyceraldehyde-3-phosphate dehydrogenase might support interaction of glyceraldehyde-3-phosphate with the enzyme. Further studies are required in order to determine the role of this structure in enzyme function.

ACKNOWLEGEMENTS

The author wishes to thank the anonymous referee and Dr. Edward Smith for many helpful suggestions and comments on the preparation of this manuscript.

APPENDIX

Comparative sequence analysis and predicted structural comparison of Glyceraldehyde-3-phosphate dehydrogenase (GADPH) and the CysP periplasmic binding protein. Identical residues are indicated by (*). Sites where amino acid residues are related by conservative replacements are indicated by (:). Sites were related by semi-conservative replacements are indicated by (.). Replacement groups for conservative replacements (in one-letter code) are (STA, NEQK, NHQK, NDEQ , QHRK, MILV, MILF, HY, FYW) and for semi-conservative replacements are (CSA, ATV, SAG, STNK, STPA, SGND, SNDEQK, NDEQHK, NEQHRK, FVLIM, HFY). Secondary structural elements are indicated by solid color coils (a-helices), coils (random coils) and rods (extended strand) along the primary sequence, Sequence interruptions are indicated by dashed line (---).



REFERENCES

1. Higgins, C.F., Gallagher. P., Hyde, S. C., Mimmack, M. L., and .Pearce,S. R. (1990). Periplasmic Binding Protein-Dependent Transport Systems: The Membrane-Associated Components. Phil. Trans. R. Soc. Lond. B. 326:353-365.

2. Davidson, A. L., Shuman, H. A., and Nikaido, H. (1992). Mechanism of Maltose Transport in *Escherichia coli:* Transmembrane Signaling By Periplasmic Binding Proteins. Proc. Natl. Acad. Sci. U.S.A., 89:2360-2364.

3. Neiditch, M. B., Federle, M. J., Pompeani, A. J., Kelly, R. C., Swem, D. L., Jeffrey, P. D., Bassler, B. L., and Hughson, F. M. (2006). Ligand-Induced Asymmetry in Histidine Sensor Kinase Complex Regulates Quorum Sensing. Cell. 126:1095-1108.

4. Felder, C. B., Graul, R. C., Lee, A. Y., Merkle, H. P., and Sadee, W. (1999).The Venus Flytrap of Periplasmic Binding Proteins: An Ancient Protein Module Present in Multiple Drug Receptors. AAPS Pharm Sci.1:E2.

5. Acher, F. C., and Bertrand, H. O. (2005). Amino Acid Recognition by Venus Flytrap Domains is Encoded in an 8-Residue Motif. Biopolymers. 80:357-366.

6. Tanabe, Y. Masayuki, M., Ishii, T., Shigemoto, R., and Nakanishi, S. (1992). A Family of Metabotropic Glutamate Receptors. Neuron. 8:169-179.

7. O'Hara, P. J., Sheppard, P. O., Thøgersen, H. , Venezia, D., Haldeman, B. A., McGrane, V., Houamed, K. M., Thomsen, C., Gilbert, T. L., and Mulvihill, E. R. (1993). The Ligand-Binding Domain in Metabotropic Glutamate Receptors is Related to Bacterial Periplasmic Binding Proteins.Neuron.11:41-52.

8. Berna, A., Bernier, F., Chabrière, E., Elias, M., Scott, K., and Suh, A. (2009). For Whom the Bell Tolls? DING Proteins in Health and Disease. Cell Mol Life Sci. 66:2205-2218.

9. Berna, A., Bernier, F., Chabrière, E., Perera, T., and Scott, K. (2008). DING Proteins; Novel Members of a Prokaryotic Phosphate-Binding Protein Superfamily Which Extends Into the Eukaryotic Kingdom. Int. J. Biochem. Cell Biol. 40:170-175.

10. Ahier, A., Rondard, P., Gouignard, N., Khayath, N,, Huang S, Trolet, J., Donoghue, D. J.,Gauthier, M., Pin, J-P., and Dissous, C. (2009). A New Family of Receptor Tyrosine Kinases with a Venus Flytrap Binding Domain in Insects and Other Invertebrates Activated by Amino Acids. PLoS One. 4:e5651.

11. Kanehisa, M., Goto, S., Sato, Y., Furumichi, M., and Tanabe, M. (2012).KEGG For Integration and Interpretation of Large-Scale Molecular Datasets. Nucleic Acids Res. 40:D109-D114.

12. Brown, N., and Lai, J. (1996). Consensus. <http://coot.embl.de/Alignment/consensus.html>.

13. Benson, D. A., Karsch-Mizrachi, I., Lipman, D. J., Ostell, J., and Sayers, E. W. (2011).GenBank. Nucleic Acids Res. 39:D32-37.

14. Bairoch, A., and Apweiler, R. (2000) The SWISS-PROT Protein Sequence Database and its Supplement TrEMBL in 2000. Nucleic Acids Res. 28:45-48.

15. Altschul, S. F., Madden, T. L., Schäffer, A. A., Zhang, J., Zhang, Z., Miller, W., and David J. Lipman, D. J. (1997). Gapped BLAST and PSI-BLAST: A New Generation of Protein Database Search Programs. Nucleic Acids Res. 25:3389-3402.

16. Hobohm, U., and Sander, C. (1995). A Sequence Property Approach to Searching Protein Databases. J. Mol. Biol. 251:390-399.

17. Combet, C., Blanchet, C., Geourjon, C. and Deléage, G. (2000). Network Protein Sequence Analysis. Trends in Biochem. Sci. 25:147-150.

18. Arnold K., Bordoli L., Kopp J., and Schwede T. (2006). The SWISS-MODEL Workspace: A Web-Based Environment for Protein Structure Homology Modelling. Bioinformatics, 22:195-201.

19. Kiefer F, Arnold K, Künzli M, Bordoli L, Schwede T (2009). The Swiss-Model Repository and Associated Resources. Nucleic Acids Res. 37:D387-D392.

20. Berman, H. M., Westbrook, J., Feng, Z., Gilliland, G., Bhat,, T. N., H. Weissig, H., Shindyalov, I. N., Bourne, P. E. (2000). The Protein Data Bank. Nucleic Acids Res. 28:235-42.

21. Hanauer, A., and Mandel J.-L. (1984). The Glyceraldehyde-3-Phosphate Dehydrogenase Gene Family: Structure of a Human cDNA and of an X Chromosome Linked Pseudogene; Amazing Complexity of the Gene Family in Mouse. EMBO J. 3:2627-2633.

22. Ercolani, L.., Florence, B., Denaro, M., and Alexander, M. (1988). Isolation and Complete Sequence of a Functional Human Glyceraldehyde-3-Phosphate Dehydrogenase Gene. J. Biol. Chem. 263:15335-15341.

23. Kisters-Woike, B., Vangierdegom, C., and Müller-Hill, B. (2000) On the Conservation of Protein Sequences in Evolution. Trends Biochem. Sci. 9:419-421.

24. Chothia, C. and Lesk, A. M. (1986). The relation between the divergence of sequence and structure in proteins. EMBO J. 5: 823–6.

Daniela Jimenez
University of North Carolina at Pembroke
Faculty Mentor:
Brandon Sanderson
Title of work:
Triptych: Inocencia Pura, Triste Rebeldia, Recuerdo

Date: 2012
Medium: Stone Lithography
Framed dimensions: 54 x 24"

Artist's Statement:
The triptych represents different stages of human life. *Inocencia Pura* leads to the birth of a child and illustrates purity and innocence. *Triste Rebeldia* is the fallowed formative years, the transition of the childhood to adolescence and the mind's propensity for chaos in that time. With this print the artist tried to express suppression of freedom on the adolescence mind. The last image of the triptych, *Recuedo*, represents the nostalgic power of memory. This series of drawings is a still life arrangement that captures each object's essence in order to express symbolic meaning.

Humanities

Idle Talk, The 'They', Death, and Anxiety as Subjects of Language Necessary to Dasein's Hermeneutic of the Self

Hannah Cloninger
Lenoir Rhyne University
Faculty Mentor: Michael Deckard
Lenoir Rhyne University

ABSTRACT
It is through Heidegger's explication of concepts such as idle talk, the 'They', death, and anxiety as well as his considerations of the importance and function of language, that one begins to see the ways in which this struggle for authenticity is undertaken. Through an examination of these concepts one can see that this struggle, or search, is waged through a hermeneutic of the self informed quite particularly by the way in which language functions within the praxis of each of these concepts. An investigation of certain sections in Being and Time reveals the particular importance and interrelation of the four above mentioned concepts to the onto-ontological and existential-ontological examination and construction of this lexically based and informed hermeneutic of the Self; this hermeneutical approach provides Dasein with a practical model for the way in which the teloi of authenticity, understanding, and wholeness may be gained.

Martin Heidegger is not regarded as one of the most influential philosophers of the twentieth century without reason, and it is not without adequate cause that his writings are considered some of the most difficult within the body of philosophic thought. The high level of complexity, and the denseness with which this complexity is communicated within the body of his work, has consequently been quite deterrent to study by many readers and scholars. However, if one is of a mind to approach Heidegger's writings, one is certain to find both the denseness and complexity immensely rewarding. This is most certainly true for the keystone of Heidegger's philosophical works, *Being and Time*, which takes as its focus an examination and reorientation of phenomenological thought and method. If one is so willing, one is certain to find some rather practical elements interspersed throughout the body of ideas presented within *Being and Time*. Heidegger's introduction of Dasein anchors the text, and the majority of his thought contained within this work centers on Dasein's search for authenticity and struggle against inauthenticity.[1] It is through Heidegger's explication of concepts like idle talk, the 'They' death, and anxiety as well as his considerations of

1 "*Authentic* moments are those in which we are most at home with ourselves, at one with ourselves. I may initiate or take up possibilities as my own; I have a deep, concrete experience of 'mineness' or 'togetherness'. However, in our more usual, normal, everyday, moments, we do not treat things as affecting us deeply in our 'ownmost' being. Heidegger thinks we live in an inauthentic way most of the time. For example, we read about a tragic death in the newspapers but don't necessarily absorb the event into our own selves or experience it personally; we don't take it personally. We are experiencing these moments *inauthentically*, experiencing them as one does, as anyone does." Dermot Moran, *Introduction to Phenomenology* (London: Routledge, 2000), 239-240.

the importance and function of language, that one begins to see the ways in which this struggle for authenticity is undertaken. Through an examination of these concepts one can see that this struggle, or search, is waged through a hermeneutic of the self informed quite particularly by the way in which language functions within the praxis of each of these concepts. An investigation of certain sections in *Being and Time* reveals the particular importance and interrelation of the four above mentioned concepts to the onto-ontological and existential-ontological examination and construction of this lexically based and informed hermeneutic of the Self; this hermeneutical approach provides Dasein with a practical model for the way in which the teloi of authenticity, understanding, and wholeness may be gained.

Before one may begin delving into such an examination of Dasein's hermeneutical endeavors with any appreciable depth, it is critically important to define Dasein, and in doing so to contextualize and understand the phenomenological misconceptions Heidegger means to address through his use of this particular term. The concept of Dasein is the product of Heidegger's attempts to explore more fully than all previous philosophers the question of Being and to delineate a satisfactory, practically workable answer.[2] In the introduction of *Being and Time* he frames both the importance of the question and the need for renewed philosophical inquiry into it, insisting that throughout the history of philosophy members of the discipline have been content to merely assert that being is a property of things which exist and end the discussion there.[3] Heidegger readily provides a rebuttal to the complacency of this notion from the outset of *Being and Time* when he writes:

On the basis of the Greeks' initial contributions towards an Interpretation of Being, a dogma has been developed which not only declares the question about the meaning of Being to be superfluous, but sanctions its complete neglect. It is said that 'Being' is the most universal and the emptiest of concepts. As such it resists every attempt at definition. Nor does this most universal and hence indefinable concept require any definition, for everyone uses it constantly and already understands what he means by it. In this way, that which the ancient philosophers found continually disturbing as something obscure and hidden has taken on a clarity and self-evidence such that if anyone continues to ask about it he is charged with an error of method.[4]

In laying this charge against his predecessors Heidegger makes a valid, though philosophically contentious, point. Additionally, the tongue-in-cheek sharpness of his rebuke easily addresses any questions about the necessity of the massive undertaking he is about to begin. Clearly defining Dasein as term, however, is not nearly as easy as providing the philosophical context and necessity for Heidegger's development of the ideas regarding Dasein itself. One of the simplest definitions of Dasein found within the text of *Being and Time* states:

Dasein is an entity which does not just occur among other entities. Rather it is ontically distinguished by the fact that, in its very Being, that being is an issue for it. But in that case, this is a constitutive state of Dasein's Being, and this implies that Dasein, in its Being, has a relationship towards that Being–a relationship which is itself one of Being. And this means further that there is some way in which Dasein understands itself in its Being, and that to some degree it does so explicitly. It is peculiar to this

2 For a discussion of Heidegger's transition from being to Dasein, see Steven Mulhall "Introduction: Heidegger's Project," in *Routledge Philosophy Guidebook to Heidegger and Being and Time*. (London: Routledge, 1996), 13-14.

3 Ibid., 1-18.

4 Martin Heidegger, *Being and Time* (San Francisco: Harper San Francisco, 1962), 2.

entity that with and through it's Being, this being is disclosed to it. Understanding of Being is itself a definite characteristic of Dasein's Being. Dasein is ontically distinctive in that it is ontological.[5]

Moran paraphrases Heidegger's explication of and work with Dasein by reducing the basic definition even further, writing: "The aim of this analysis is to show up Dasein as having the fundamental structure of Being-in-the-world, being with things and with others in such a way that its whole existence is structured by care (Sorge). As Heidegger puts it, the existential meaning of Dasein is care."[6] Reading these excerpts one begins to understand quite clearly that the most defining trait of Dasein is that Dasein is able to consider its own Being. To clarify and qualify this passage further it is helpful to turn to Moran, who writes that "Dasein is not an entity that stands on its own, like a stone or a chair; it is always caught up in a world. Only Dasein can be really said to have a world; Heidegger thought natural things strictly speaking had no world, and animals were at best "world poor" (Weltarm). The fundamental nature of Dasein is always to be in a world."[7] Dasein is always already thrown into a world, and Dasein's capability for self-reflexive thought–which allows it to examine the world and its Being-in-relation-to-the-world– is what separates Dasein from granite or a rhododendron or an aardvark. Dasein's knowledge of such entities as these, distinguished as ontical knowledge, is separate from Dasein's ontological knowledge of Being in relation to these entities. Because Dasein is capable of the reflexive thought which allows it to examine, contemplate, and even alter its own Being-within-the-world and Being-in-relation-to-the-world, Dasein is no mere entity. Dasein's ability to consider itself, and therefore to orient itself towards the nature and structure of its own self through careful[8] examination, transports it from the realm of entity (granite, rhododendron, aardvark) into the realm of Being.[9]

Because Dasein is capable of the ontological knowledge which makes it aware of its Being and its modes of Being– the ways in which it conscientiously seeks to be towards itself and to be towards entities and other ontological Beings–Dasein is faced with the particular dilemma of choosing *how* it is to be and *towards* what and whom it seeks to be orienting itself. This constant processing loop of self-awareness and feedback that occurs within a Being within the world creates an interesting dilemma for Dasein, and this dilemma necessitates a solution. The dilemma which Dasein faces is how it can successfully negotiate being involved with and part of the world and yet remain in key ways apart from the world. Dasein's perpetual quandary is, quite simply, individuation. Every human being, every Dasein, is well versed in this dilemma long before it is even aware that the dilemma exists. An infant learns that it is separate from its parents and siblings; many children have a favorite stuffed animal that they cannot be without; boys and girls understand early on that they are different from each other because they play different games and are given different toys and wear different kinds of clothes. Every Dasein is thrown into a world which is must either accept or reject, which feels either authentic or inauthentic to its Being. More than that, every Dasein is constantly being thrown into a world that is perpetually changing;

5 Ibid., 32.

6 Moran, *Introduction to Phenomenology*, 238.

7 Ibid., 233.

8 "Careful" is used here to suggest in the senses of both cautious safety and thoughtful attentiveness.

9 For expansion on this point, see William Blattner, "Reading the Text: Metaphysical Idealism and Realism," in *Heidegger's Being and Time: A Reader's Guide*, (London: Continuum, 2006), 116-117.

as Being experiences the world and itself in relationship with each other it constantly reformulates its knowledge and opinion of both. This interpretative act does not cease. For Dasein it is habit, and for Heidegger this precise action is the core of the hermeneutical nature of phenomenological experience. "By 'hermeneutics' Heidegger does not just mean the method specific to the historical and cultural sciences, but the whole manner in which human existence is interpretive."[10] Once it is recognized by Dasein, this hermeneutic of experience loses is closed form and opens outward for a conscientious investigation of itself.[11]

When Dasein is thrown into a world, it is always also thrown into the language of that world. Be it English, German, Russian, or simply the technical jargon of a certain trade or the slang of a particular subculture, language is part of a world in such an integral way that it shapes the world. Language is the means not only of communication, but of interpretation, and Dasein communicates with itself through the medium of language just as it communicates with another Dasein through said medium. Language is the medium through which Dasein seeks to make *everything* intelligible, and in doing so to seek authenticity and reject inauthenticity. Heidegger heavily emphasizes this fact, and the implications it holds for Dasein, in Section 34 of *Being and Time*, entitled "Being-there and Discourse. Language".

> *The fundamental existentialia which constitute the Being of the "there", the disclosedness of Being-in-the-World, are states of mind and understanding. In understanding, there lurks the possibility of interpretation-that is, of appropriating what is understood. In so far as a state-of-mind is equiprimordial with an act of understanding, it maintains itself in a certain understanding. Thus there corresponds to it a certain capacity for getting interpreted. We have seen that assertion is derived from interpretation, and this is an extreme case of it. In clarifying the third signification of assertion as communication (speaking forth), we were led to concepts of "saying" and "speaking", to which we had purposely given no attention up to that point. The fact that language now becomes our theme for the first time will indicate that this phenomenon has its roots in the existential constitution of Dasein's disclosedness. The existential-ontological foundation of language is discourse or talk.*[12]

Here Heidegger begins to delve into the hermeneutics of self, with particular emphasis on the effect it has on Dasein's experience as a Being and its interpretation its and Being. Because Dasein uses language as a tool for communication not only with other Daseins but also with itself, and because language is used in both idle talk with Others and in the internal interpretation of all *existentialia*,[13] language serves a number of functions that are integral to the search for authenticity. Moreover, because language does act in so many divergent ways within Dasein's consideration of itself and within Dasein's interaction with Others and with the world, Dasein's reliance on language is bound to be at times a source of both authenticity and inauthenticity in each circumstance where it is used; namely, all circumstances. Heidegger highlights this

10 Moran, *Introduction to Phenomenology,* 235.

11 Ibid., 237.

12 Heidegger, Being and Time, 203.

13 "Existentialia (plural) are certain characteristics of Dasein that are revealed by the analysis of its existence. In Heideggerian terms, an existentiale (singular) concerns Dasein's residing alongside the world and its involvement with entities within the world which is always expressed in terms of care and concern . . . Using the existentiale we may discern some notable patterns in the manifold impressions of Being." Munday, Roderick. "Glossary of Terms in *Being and Time*". *On Reading Being and Time: An Explication and Commentary*, March 2009, <http://www.visual-memory.co.uk/b_resources/b_and_t_glossary.html>.

with his assertion that for Dasein an act of understanding often leads to interpreting and appropriating that which is supposedly understood, and this understanding in turn leads to assertion.

However, complicating the function of language to Dasein is the existence of idle talk, as well as the problems posed by Dasein's relationship to the entity which Heidegger terms the 'They'. Experience is not common, but language is, and because language falls between Dasein and the 'They' Dasein does not have a monopoly on the meanings implied within language. Even the meanings Dasein intends cannot always hold up to the interpretive appropriation of another Dasein. This area into which language falls might, for the purpose of this examination, be termed a middle ground of intelligibility, and this middle ground is where Heidegger's discussion of idle talk becomes crucial. In section 35 of *Being and Time*, Heidegger writes:

The expression 'idle talk' ["Gerede"] is not to be used here in a 'disparaging' signification. Terminologically, it signifies a positive phenomenon which constitutes the kind of Being of everyday Dasein's understanding and interpreting. For the most part, discourse is expressed by being spoken out, and has always been so expressed; it is language. But in that case understanding and interpretation already lie in what has thus been expressed.[14]

In his commentary on this section within *Being and Time*, Gelven simplifies the gist of this section quite understandably with the following explanation.

. . . the chattering enthusiasm of those who find everything in the world "interesting" but never relevant. The noncommittal and hated "That's interesting!" often suggests a kind of unconcern that is far more unpalatable than a direct statement of dislike. Idle talk also refers to those who constantly present a great number of facts and statistics as substitute for rational inquiry, as if through some magic a more exact statistical rendering of what is an obvious fact will somehow generate of itself an understanding of what the problem is or what ought to be done. All of these are examples of what Heidegger calls idle talk (Gerede), and it is the manner in which the inauthentic they-self articulates its subtle smoke screens, which hide the genuine skill of language to expose the workings of what it means to be.[15]

Here, and in other places in this section, Heidegger either implicitly or explicitly states that idle talk is occurring in this sort of middle ground of intelligibility that is external to every individual Dasein, but which every individual Dasein participates in in some way or another through the shared use of language as a communicative mode of Being. This middle ground of intelligibility exists because each Dasein is limited to the authenticity and inauthenticity of its own Being-in-the-World and by its own particular understanding of the language being used; to put that in Nietzschean terms, every Dasein is limited by its own horizons of experience. It is this which makes the middle ground of intelligibility so fundamental to Dasein's Being-in-the-World and to Dasein's Being-with-Others. Because idle talk is paramount to Dasein's Being in and interacting with the world it is vital to connect both the existence and function of idle talk to Heidegger's ideas regarding Dasein's phenomenological hermeneutic.

In Section 27, "Everyday Being-one's-Self and the 'They'," one of several sections which focuses on an explication of the 'They', Heidegger writes:

14 Heidegger, *Being and Time*, 211.

15 Michael Gelven, *A Commentary on Heidegger's Being and Time* (New York: Harper & Row, Publishers, Inc, 1970), 107

The 'They' is there alongside everywhere [ist uberall dabei], but in such a manner that it has always stolen away whenever Dasein presses for a decision. Yet because the 'They' presents every judgment and decision as its own, it deprives the particular Dasein of its answerability. The 'They' can, as it were, manage to have 'them' constantly invoking it. It can be answerable for everything most easily, because it is not someone who needs to vouch for anything. It 'was' always the 'They' who did it, and yet it can be said that it has been 'no one'. In Dasein's everydayness the agency through which most things come about is one of which we must say that 'it was no one.'[16]

I would argue that much of this thought regarding the 'They' can be applied analogously to idle talk. Idle talk is not something from which any Dasein can escape; Heidegger asserts that idle talk is fundamental to Dasein's average everydayness; it is essential to just getting on with one's life, as is existence for Dasein as part of the 'They'. Gelven simplifies and agrees with this point, writing:

Everyone will readily admit that daily concerns can take one's mind off the awareness of the self. But if this is true, it means that since one does manifest different modes of Being, then it is necessary that there be different modes. The task, then , of one who is pursuing the analysis of the self is to render and account of the phenomenon that does indeed occur– namely, that sometimes I lose the awareness of myself in concern for daily affairs. In order to make the analysis easier we give names to these modes: the one in which I am aware of the self I give a name, the "self-mode" (i.e., eigentlicht: "authentic"). The other, merely for convenience' sake, I call the "non-self-mode" (uneigenlich: "inauthentic").[17]

As Gelven highlights, Dasein is able to determine authenticity and inauthenticity is this way and in doing so must be able to assert its individuality as a singular Being whom is separable from the 'They' and which is capable of answering for itself. It must wade through the middle ground of shared phenomena, eking out personal intelligibility through an appropriation of language while maintaining a personal experience conducive to the development of authenticity.

It is important to understand and remember that because idle talk and the 'They' will never attain Being, but will only ever be mere entities, they are at their most fundamental level of ontic existence inauthentic. Ontic entities are precluded from authenticity by the very fact of their fundamental inability to foster ontological existence through ontological knowledge about and development of Being. Because idle talk has no way of achieving an ontological authenticity, it is able to produce answers that might be simply convenient to Dasein, or that might aid Dasein in defining or differentiating itself from either all or a particular few other Daseins, in the center of which this middle ground of intelligibility is located. Idle talk has no way of answering for itself, just as the 'They' has no way of answering for itself, and as such both can be molded or made to answer in ways that are advantageous, convenient, or possibly self-deceptive and damaging to the individual Dasein. Blattner's comments about curiosity further emphasize this point about the damaging possibilities of idle talk in particular as well.

Curiosity deepens our immersion in idle talk. Curiosity, rooted in our fascination with the world, emerges in the possibility of "seeing the 'world' merely as it looks while while one tarries and takes a rest" . . . When we merely look at a thing and are, perhaps, delighted by it, we experience a disengaged and at best positive experience of it. We do not, in any case, gain original familiarity this way. There is a heightened form of curiosity, however, in which "curiosity has become free" and we look

16 Heidegger, *Being and Time*, 165.

17 Gelven, Heidegger's *Being and Time*, 69.

"just in order to see," rather than to understand. Such curiosity leads to distraction, and distraction is a positive roadblock to original understanding. Heightened curiosity thereby contributes to the degradation of understanding.[18]

So while it is certainly possible to turn the hermeneutical circle of Dasein's phenomena to its advantage and develop authenticity, it is also possible for Dasein to fall away–unwillingly or willingly–from authenticity and become so trapped in its outward persona and appearance that all attempts at authentic Being are rendered impossible.[19] The process is far from simple and much less than straightforward; pitfalls abound, and both knowledge, ignorance, and curiosity contain possibilities for a disruption in the pursuit of understanding.

Not all is lost, however, and to repeat an earlier point, Dasein is separable from this middle ground through reflexive thought, a quality which it is certain that it has, and which it is certain that an Other has, or that Others have. But Dasein either cannot or does not ascribe self-reflexivity to the 'They'. If the 'They' were capable of self-reflexive thought, it would be able to answer for itself. The 'They' can be invoked and described as Dasein needs it to inform its own self-reflexive processes and definitions, but because the 'They' is an inauthentic labeling of an entity that is incapable of ontological authenticity, any sort of definition Dasein finds for itself through its invoking of the 'They' and through the influence of idle talk is also partially inauthentic. The selection of relevant subjects, ideals, and languages may be arbitrary or quite pointedly intentional, but just as Dasein is incapable of escaping its world in which these modes mix, it is also faced with the near impossible goal of achieving authenticity while under the influence of inauthentic sources.

Because Dasein relies so heavily on these inauthentic sources for material and information that it may deem necessary to the formation of authentic Being, the sheer magnitude of Dasein's continual struggles for authenticity and against inauthenticity should be neither shocking nor underestimated. Even Heidegger himself deems a truly and completely authentic existence almost impossible to attain, making the argument that we are entrenched in inauthenticity out of force of habit.[20] One could infer, based on Heidegger's characterization and qualification of Dasein throughout *Being and Time*, that Dasein, is acutely, even if subconsciously, aware of its own inauthenticity, and of the inauthenticity of the methods and sources it uses in its attempts to mine authenticity. This awareness, even if deeply repressed in the subconscious, is a major cause of the angst that a Dasein encounters throughout its life. It is arguably the chief cause of anxiety, both about existence itself and about death, the moment at which all strivings and attempts at an authentic existence must necessarily cease.

The moment in which Dasein becomes aware of its own mortality, it immediately begins to orient itself around and towards the end of its own existence, knowing that with both the finite nature of its Being and the moment of finality which it must at some time face, there also comes an end to its search for authenticity. This awareness may be fully conscious, deeply ingrained in the subconscious, or located somewhere in between, but wherever along that spectrum this awareness resides, the deadline which death[21] gives to Dasein becomes both a

18 Blattner, Heidegger's *Being and Time*, 135.

19 Moran, *Introduction to Phenomenology*, 243.

20 Ibid., 240.

21 "When Heidegger speaks of death, he is not speaking of how one thinks at the time in which one is dying. For the conditions of death are often not geared toward reflection at all. What is important in this analysis

motivation for the search for authenticity and a source of anxiety. Moran emphasizes the crucial connection between anxiety and death in Being and Time thusly:

Human nature is radically finite. It ends in death. Each of us is directed towards death, as the annihilation of all our projects, as that which casts a shadow over all our projects and engagements. . . . Heidegger recognizes the centrality of being-towards-death (Sein-zum-Tode) in humans. Moreover, death can only be authentically experienced by us if we become totally secure with our first person experience of dying – our genuine anticipation of death. We cannot experience other people's deaths in the same authentic manner.[22]

Because Dasein exists only for the sake of itself, because only an individual Dasein can define itself and build it's own authenticity, the end of both itself and its search looms with menacing inescapability. Death, and the angst it produces, has the ability to take the pursuit of authenticity and make it a frantic and hurried goal to be reached. For Heidegger, death makes authenticity a telos, the ultimate but almost impossible telos.

In section 46, under the heading of "Dasein's Possibility of Being-a-Whole, and Being-Towards-Death", Heidegger writes:

Yet the primary item in care is the 'ahead-of-itself', and this means that in every case Dasein exists for the sake of itself. 'As long as it is', right to its end, it comports itself towards its potentiality-for-Being. Even when it still exists but has nothing more 'before it' and has 'settled...its account', its Being is still determined by the 'ahead-of-itself'.[23]

Here Heidegger has clarified both Dasein's existence for its own sake and the reasons for the nature of such an existence. Moreover, he has expounded Dasein's existence for itself by making clear to the reader that because the "primary item in care is the 'ahead-of-itself'", Dasein is necessarily and contingently oriented towards its own potentiality-for-Being. The potentiality-for-Being is in an ongoing process of realization that cannot be ceased until the moment of death, when Dasein, whether authentic or not, has reached the full sum of its potential and has finally reached the totality of it possible wholeness. In his discussion of the first section within Division Two of *Being and Time* Mulhall expounds upon this point briefly.

In short, an authentic confrontation with death reveals Dasein as essentially thrown projection, its relation to its own Being at once holding open the possibility, and imposing the responsibility, of living a life that is both genuinely individual and genuinely whole – a life of integrity, of authenticity. For Dasein to acknowledge its mortality – to anticipate death – is for it to acknowledge one of the most fundamental limits or conditions of its existence. And it can do so only by acting upon the knowledge that it is authentically itself only when, as concernful Being-alongside (entities) and solicitous Being-with (others), it projects itself upon its ownmost potentiality-for-being rather than the possibility of the they-self.[24]

It is in the recognition of death that Dasein becomes aware of both its potentiality for authentic wholeness and the temporal limits that are placed upon its endeavors to achieve such goals while it is within the world.

In light of this, one could argue that because Dasein seeks means of definition through modes such as the 'They' and idle

is not how one actually feels at the moment of death, but *what impending death can mean to one in the fullness of one's life.*" Gelven, Heidegger's *Being and Time*, 145.

22 Moran, *Introduction to Phenomenology*, 241.

23 Heidegger, *Being and Time*, 279.

24 Mulhall, Heidegger and *Being and Time*, 120.

talk, which are at base ontically inauthentic entities, it is very likely that Dasein spends most of its existence in a state of inauthentic fallenness from which it seeks but cannot always find means of escape. It is here that we can find most strikingly the relationship between idle talk, the 'They', anxiety, and death as they relate singularly and in conjunction to Dasein's search for authenticity. In the midst of this particularly complex problem it becomes essential to return to several sentences in Section 46 of *Being and Time*.

Hopelessness, for instance, does not tear Dasein away from its possibilities, but is only one of its own modes of Being towards these possibilities. Even when one is without Illusions and 'is ready for anything'...here too the 'ahead-of-itself' lies hidden. The 'ahead-of-itself', as an item in the structure of care, tells us unambiguously that in Dasein there is always something still outstanding, which, as a potentiality-for-Being for Dasein itself, has not yet become 'actual'. It is essential to the basic constitution of Dasein that there is constantly something still to be settled .... Such a lack of totality signifies that there is something still outstanding in one's potentiality-for-Being.[25]

So it is through Heidegger's explication of modes of being such as hopelessness and anxiety, modes that are in themselves authentic, that one sees that Dasein is never resigned completely and finally to a stagnancy produced by inauthenticity and inauthentic modes of being. Moreover, hopelessness and anxiety, because they can be, and often are, directed towards Dasein's 'ahead-of-itself' and Dasein's potentiality-for-being, are a means of individualizing Dasein and providing a mode of Being that can authentically liberate Dasein from the inauthenticity of idle talk and the 'They'. This is so because even though anxiety and hopelessness are both made accessible through encounters with the 'They' and the use of idle talk, like all other ideas and concepts, are not understood by Dasein until Dasein encounters them for itself. But it is heavily implied that moments of true, Heideggerian anxiety are not commonplace occurrences; anxiety is still a subject of idle talk and falls prey to the shortcomings of the middle ground of intelligibility.

It may at this point be useful to return to Heidegger's discussion of the way in which anxiety as a mode of Being operates with an authenticity that provides for Dasein true individualization. In Section 40, Heidegger writes:

On the contrary, the rarity of the phenomenon is an index that Dasein, which for the most part remains concealed from itself in its authenticity because of the way in which things have been publicly interpreted by the 'They', becomes disclosable in a primordial sense in this basic state-of-mind.

Of course it is essential to every state-of-mind that in each case Being-in-the-world should be fully disclosed in all those items which are constitutive for it,--world, Being-in, Self. But in anxiety there lies the possibility of a disclosure which is quite distinctive; for anxiety individualizes. This individualization brings Dasein back from its falling, and makes manifest to it that authenticity and inauthenticity are possibilities of its Being. These basic possibilities of Dasein (and Dasein is in each case mine) show themselves in anxiety as they are in themselves--undisguised by entities within-the-world, to which, proximally and for the most part, Dasein clings.[26]

By here establishing the way in which Dasein may achieve authentic individualization, namely through moments of angst with absolute particularity exclusive to Dasein, Heidegger makes it clear that Dasein does have viable access to authenticity through the mode of such

25 Heidegger, *Being and Time*, 279.

26 Ibid., 235.

a highly individualized and exclusive phenomena. The anxiety which an individual Dasein experiences cannot be fully echoed or replicated by any other Dasein. Once again, anxiety is of course subject to idle talk, but the fundamentally inauthentic ontical existence of idle talk makes the communication of a fundamentally authentic experience impossible between one Dasein and other Daseins through said medium.

This quite clearly leads Dasein into the sort of hermeneutical circle that necessarily continues until the moment of death; in the mean time both Dasein and this circle must take into consideration all *existentialia* -idle talk, understanding, doubt, anxiety, hopelessness, and all other states of mind which constitute Dasein's there-ness and disclosedness of Being-in-the-World. *Existentialia* and language, and every facet of Dasein's existence to which they apply or by which they are influenced, are integral to the onto-ontological and existential-ontological foundations of Dasein.

Through an examination of Heidegger's presentation of idle talk, the 'They', death, and anxiety in *Being and Time* one is given access to a route by which, with the aid of language, the Heideggerian telos of authenticity–of true and ownmost individuality–may be achieved. Each of these concepts aids Dasein in gaining both an onto-ontological and existential-ontological understanding of itself through a careful examination of the impact each has, separately and in conjunction with each other, upon Dasein's structure and formulation as it is constantly changing throughout Dasein's existence. This process of constant change occurs through a hermeneutic of the self, which is based in and informed by Dasein's reliance on language for intelligibility both within and without its conception of itself. The ongoing and cyclical nature of hermeneutical understanding that continues until the moment of death plays a crucial role in Dasein's attempts to avoid inauthenticity, and to achieve a wholeness that appears not solely in those moments of retrospection prior to its end. Dasein, for it's own sake and for its own intelligibility, needs to be able to strive for temporary versions of wholeness that make its own existence seem relevant and coherent; however elusive and unstable these flawed versions of wholeness may be, it is fundamental to Dasein's continued efforts towards authenticity and authentic wholeness. It is then possible for this Heideggerian hermeneutic of the self to provide Dasein with practical, albeit inauthentic, ways to seek the authentic wholeness and understanding which it desires.

Works Cited

Audi, Robert. "Heidegger, Martin." In The Cambridge Dictionary of Philosophy, 2nd ed., 370-373. Cambridge: Cambridge University Press, 1995.

Audi, Robert. "Phenomenology." In The Cambridge Dictionary of Philosophy, 2nd ed., 664-666. Cambridge: Cambridge University Press, 1995.

Blattner, William D. Heidegger's Being and Time: A Reader's Guide. London: Continuum, 2006.

Gelven, Michael. A Commentary on Heidegger's Being and Time, 1st ed. New York: Harper & Row, Publishers, Inc., 1970.

Heidegger, Martin. Being and Time. San Francisco: HarperSanFrancisco, 1962.

Korab-Karpowicz, W.J. "Martin Heidegger." International Encyclopedia of Philosophy, last modified December 21, 2009, <http://www.iep.utm.edu/heidegge/>.

Moran, Dermot. "Heidegger's Being and Time." In Introduction to Phenomenology, 222-247. New York: Routledge, 2000.

Mulhall, Stephen. Routledge Philosophy Guidebook to Heidegger and Being and Time. London: Routledge, 1996.

Munday, Roderick. "Glossary of Terms in Being and Time". On Reading Being and Time: An Explication and Commentary, last modified March 2009, <http://www.visual-memory.co.uk/b_resources/b_and_t_glossary.html>.

Wrathall, Mark A. How to Read Heidegger. New York: W.W. Norton, 2006.

Schiller's Alchemical Education: Conceptualizing Art as the Philosopher's Stone

Andrew Jester
East Carolina University
Faculty Mentor: David Smith
East Carolina University

ABSTRACT
In "On the Aesthetic Education of Man", Friedrich Schiller develops an art theory asserting that aesthetics can resolve human conflict while empowering the individual. However, it is often unclear as to how Schiller's proposals are to be practiced and achieved. I claim that Schiller's theory appropriates alchemical concepts, thereby identifying a cause for his theory's obtuseness, and clarifying how the processes are to be understood. Schiller's appropriation of alchemy is evinced through an overview of Schiller's claims, evidence that alchemical information was available to Schiller, and a demonstration that the features and goals of Schiller's theory are similar to those of the alchemists' processes. From there, I support the claim that Schiller employs alchemical concepts by identifying how the underlying structure of his assertions, and his diction, correspond with the alchemists' preparatio, putrefactio, and hierogamy.

The nascent stage of the French Revolution was hailed initially as the triumph of reason over emotions, and was thus seen as the culmination of the Enlightenment projects, a belief held by men such as Thomas Jefferson and expressed in Thomas Paine's *Rights of Man*; yet the Reign of Terror quickly dissolved such lofty hopes, as many citizens were brutally murdered. This violence suggested that emotions have the greater influence upon humankind's actions, and that this imbalance fosters societal disorder and decline, as well as irrational egoism. The failure of reason to sweep over the world, and with it the possibility to settle all differences peacefully through debate, compelled Friedrich Schiller to explain the cause of this breakdown and to identify how the vision of universal reason might be attained. Schiller's theory, presented in *On The Aesthetic Education of Man*, claims that in order to be liberated from two potentially domineering impulses, rationality and emotionality, humankind must harmonize them by creating and contemplating art.

Schiller's theory is obtuse; he often employs poetic language in place of deduction, there is little instruction regarding how to practice his assertions, and it is unclear how the claimed effects of his theory are achieved. If we recognize that Schiller appropriated alchemical concepts,[1] then we may dissipate the obscurity of Schiller's theory. The process of evincing Schiller's appropriation begins with an overview of Schiller's claims, as this will aid in recognizing parallels with alchemical concepts. As we will see below, Schiller would have been familiar with alchemical operations thanks to his friendship with Goethe and the academic environment

1 While one usually speaks of alchemical "processes," I have chosen to use the term "concepts" because I wish to include the images and phrases used by alchemists to communicate the stages and processes of the alchemical work, and not just the processes themselves.

in which he worked. Having identified plausible alchemical resources, the features and goals of the alchemical process are shown to be similar to the features and goals of Schiller's theory. In particular, Schiller's diction and concepts emulate three stages of the alchemical process: the *preparatio*, the *putrefactio*, and the *hierogamy*.[2] As will also become apparent, knowledge of this triadic sequence of stages allows one to clarify Schiller's abstract processes for developing the ideal self.

An overview of Schiller's claims concerning the aesthetic education assists in the identification of alchemical concepts at play in Schiller's discourse. Schiller claimed that man oscillates between two impulses: the rational, which he termed the formal impulse, and the emotional, termed the sensuous impulse. The sensuous impulse renders man an object in time, in which man merely responds to a sequence of changes; the sensuous impulse turns man into matter (Schiller 64). The formal impulse is supposed to proceed from man's "rational nature" and strives to bring harmony (65). Reason, according to Schiller, ought to harmonize our existence, yet reason can be said to operate through division, not harmonization ¬– an approximation of how Schiller resolves this contradiction will be addressed through the later delineation of alchemical stages. This harmonizing formal impulse cannot succeed upon a society that acts on unrestrained emotion. Schiller proposes that to resolve this unbalanced situation, we must first become aesthetic, a state in which the creation and contemplation of art can train humankind's emotions, so that the emotions energize our efforts to act according to the formal impulse. Only after achieving this aesthetic state can we attain the rational. Despite the disparities arising from our differing cultures, all can be harmoniously unified through our creation and contemplation of art. For Schiller, art is a representation of our shared humanity, and humanity implies the shared conflict we feel between our formal and our sensuous impulses. He claims that we can harmonize humankind's two contrary impulses through the play impulse, in which we create beauty. Beauty is achieved when the artist harmoniously conjoins abstract concepts with the material; metaphorically, rational concepts fill in and animate the objects used in constructing art (Schiller 81-7). As will become evident below, these claims borrow from alchemical thought, the history and practice of which would have been familiar to Schiller, given his education and circle of friends.

Alchemy is most commonly known as the transmutation of base metals into gold, lending support to its derision by many as mere mysticism; however, throughout the history of its development, and in Schiller's time, alchemy's ability to lend itself to metaphor ensured its value independent of the promise of monetary gain. Martin Luther appreciated it as an allegory for "the resurrection of the dead at the Last Day" (Eliade 191); throughout the Renaissance, Neo-Platonists appreciated it as a metaphor for the ascent of the soul and the redemption of man. During the Enlightenment, the processes of alchemy were valued for their exploration of dividing properties, and in its ability to create a new product. Within the Enlightenment period, individuals such as Newton and Goethe valued alchemy's function as a model for the workings of the universe (Eliade 231-33). Goethe himself practiced it, as he states in his autobiography, "I concealed from Herder my mystico-cabalistical chemistry, and everything relating to it; although at the same time, I was still very fond of secretly busying myself in working it out more

2 This triadic structure invites comparison to Hegelian dialectics; Hegel would have developed his claims after Schiller's work had been published. Investigating correlations and potential influences may prove fruitful.

consistently than it had been communicated to me" (357); this autobiographical evidence, coupled with Goethe's well-known friendship and correspondence with Schiller, provides reason to believe that the concepts of the alchemist were available to Schiller. That Schiller did re-employ the symbolic potential of alchemy is leant more plausibility through the work of Paul Bishop, who mentions how Schiller's use of certain terms throughout his works "all have overtones of alchemy or freemasonry, areas probably Goethe brought to his attention" (Bishop 141). Additionally, Bishop notes that Goethe had written a work associating alchemy with a form of education that would enable man to no longer be ruled by his emotions[3] (141).

From these available resources concerning alchemical thought, Schiller would have found features in alchemy that were attractive to him, as they corresponded with his goals within the *Aesthetic Education.* The alchemist understood that the true aim, the true masterwork, was the transmutation of the alchemist himself – he was to become the liberated, purified material. As the alchemist performed his processes on the metal, often practicing celibacy and fasting while doing so, he was working those processes on himself – turning himself into his "golden state," an ideal state in which he would not be violable by the ravages of the human condition, as temporal matter sentenced to a finite existence (Eliade 159). Schiller's goal of liberating man from unruly emotions relates to alchemy's processes and objectives, as the alchemist understood the true intent of alchemy as the purification of the self to achieve the quality of gold, as gold is immune to the ravages of time. It had been thought that all metals naturally developed into gold, but the natural passing of time was too slow. Through alchemical processes, man could assist time, so that he and the materials he experimented with were accelerated toward the ideal versions of themselves (Eliade 169). The culmination of the alchemical processes produced a material termed the philosopher's stone, which could transmute other metals into gold upon contact, and could be liquefied and imbibed by an individual, endowing them with youth and health. From this manipulation of matter, we see that the alchemist could assist time, and liberate man and nature from existing merely as finite material suspect to corruption, or impurity. This goal of the alchemist approximates Schiller's understanding of art's positive effects, as he claims that art can help humankind attain "the perfection of his being" through the aesthetic appreciation of art; humankind must only be taught how to do so (73).

Schiller's goal resembles that of the alchemist. The attainment of an ideal self that is equivalent to the purified state offered by alchemy is expressed by Schiller when he presents the concept of the "pure ideal man" (31), as he claims that "Every individual man…carries in disposition and determination a pure ideal man within himself, with whose unalterable unity it is the great task of his existence…to harmonize" (31). What Schiller identifies as the pure ideal man is the same objective of the alchemist, but the alchemist identifies the objective as the philosopher's stone. The task of achieving this objective is complicated by the impulses that humankind is subjected to. Schiller describes the conflicts resulting from our impulses, and their ensuing effects, when he states, "Nature demands multiplicity" (32), while reason "finds combination only through dissolution…" and "in order to seize the fleeting appearance [reason] must bind it in the fetters of rule, dissect its fair body into abstract notions, and preserve its living spirit in a sorry skeleton of words"

3 Paul Bishop states that this may be found within Goethe's *History of the Theory of Colours*, in the section entitled "Alchemists."

(24). The institutions that authorize truth in our lives present words sans feeling, i.e. principles are formulated and enforced rather than freely chosen, while our emotions in response to the natural world threaten to become unruly – we are determined, and the relativist rejoices. For Schiller, art is supposed to highlight these determiners for the artist and the audience, leading to liberation from a potentially repressive rational impulse, and from untamed passions. Alchemy reveals itself to be the inspiration for Schiller's remedy to this conflicted condition, and, as it does so, it helps explain certain obtuse features within Schiller's claims.

Comprehending the actualization of Schiller's claims leads to confusion. Schiller's process of highlighting the dilemmas facing humankind, and therefore the attractiveness of a reconciling factor, is keen. Similar to the alchemical concern with the corruption of matter, Schiller believed that man is corrupted by existing within a *certain* time, and that our political institutions use force to impose harmony, while failing to train our emotions (Sharpe 152). Art, Schiller claims, allows us to realize what is true for all time, thereby purifying us of our corruptions from thinking and acting as creatures determined by a specific time (Schiller 64-7). The artist is able to deliver the ideal to the audience, because the artist conjoins matter and abstraction so that the viewer grasps this union and is "educated;" theoretically, moral conduct is to become second nature (Sharpe 155). This notion sounds quite appealing, as it presents the possibility of morality chosen by all because of our interaction with art. Yet how is it achieved? Have artists failed, or has the audience failed to follow a necessary process of contemplation? These questions hone in on a crucial criticism of Schiller's work, as the ideal process of creating and contemplating art appears as mystifying as alchemy is mystical. Having noted the similarities between the goals of Schiller's theory and alchemy, the triadic sequence that Schiller appropriated from alchemy may begin to be discussed; recognizing this structure and its implications assists the reader in understanding Schiller's intentions.

The alchemist achieved his transmutation to gold, and his attainment of the ideal self, through repeating the processes of *preparatio*, *putrefactio*, and the *hierogamy*. The preparatio is the distillation process, "the process of purification and clarification whereby the volatile spirit is extracted from the impure matter or body" (Abraham 55). The alchemist claims that following the *preparatio*, the soul ascends un-tethered by the corrupted material. Schiller would understand this ascent of the soul as the mind of the individual ascending to the intellectual realm; this interpretation is an appropriation of the alchemist's distillation process of burning away the impurities accumulated through existence in time. Schiller's use of the *preparatio* concept is evinced when he claims that the secret of the master artist is his "annihilating the material by means of the form" (Schiller 106). Schiller's re-conceptualization of the *preparatio* is further demonstrated when he states "Man has *risen* [emphasis added] to a *unit of idea* embracing the whole realm of phenomena. By this operation we are no more in time, but time…is in us" (67). This process mirrors the alchemist's goal of the *preparatio*, as "During this phase the body is made spiritual and the spirit made corporeal" (Abraham 56).

When Schiller states that "[man] is to eradicate in himself everything that is merely world, and produce harmony in all its mutations" (63-64), he employs the alchemical concept of the *preparatio*, the removal of accrued determiners, or impurities. The *preparatio* is the torturing of the object for the removal of impurities accumulated by existing as matter, and

we can understand Schiller's statement of "annihilating the material by means of the form" (106) as meaning that as the artist creates, he tortures and burns away the determiners of mankind's disparate histories and cultures, discovering what is true and what is possible for all men, for all time. We are brought back to the alchemist's aim of *assisting* time, rather than being determined by it. Time allows development, which is necessary, but it serves as a boundary that can easily limit humankind's productive activity (64). Rather than be determined by the boundaries of our specific time, alchemy enables humankind a more active role. Schiller assigns art the role of alchemy, as he claims that the creation and contemplation of art enables humankind to enact a more active role in their development, i.e. humankind can more readily achieve its potential through interaction with art. This claim, once again, enjoins questions as to how the liberation from cultural boundaries and man's assistance of time, rather than his determination by it, might be actualized. Perhaps more frustratingly, how is truth recognized and advocated, especially in a postmodern, postcolonial world?

Schiller parts these potentially chaotic waters be appropriating the alchemist's *putrefactio*, the second stage of the triadic sequence. Schiller had already identified this problem of "truth," or meaning, as he notes that our concepts can lead to contradictions, for they are fluid attempts at organizing our perceptions; the problem of truth is expressed when Schiller states that "Every other condition into which we can come refers us to some previous one, and requires for its solution some other condition" (103); to resolve this Derridean sea of signifiers, our concepts must be purified through distillation, the alchemist's *preparatio*. Art allows the distillation of our concepts, of our emotional responses to the world, because it releases us from the determiners of our particular place in time; we die, the soul is released outside of time, and our intellect functions unencumbered. Schiller borrows from alchemy when he claims that: "the aesthetic alone is a whole in itself [because in it] alone do we feel ourselves snatched outside of time" (103). To leave the realm of time, we experience death; thus we are brought to the second stage of alchemy – the *putrefactio*.

The *putrefactio* is the death that always follows the *preparatio* (Eliade 152). The material dies after the *preparatio*, the torturing. The distillation makes the material transition into a vapor. Gas is produced, and the symbolism becomes obvious – the soul leaves the body, or is "snatched outside of time" (Schiller 103). The soul that has existed in time has been corrupted, or determined. The risen soul now exists outside of time, and realizes all that is rational, and all that is in man's power to perform. The material, the body that the soul has left behind, is now the alchemical *prima materia* (Eliade 154-57), the primal material that has not accumulated impurities through existing in time. It has returned to a pre-created state, one that has not been determined. When Schiller says that the creation and contemplation of art allows us to be "snatched outside of time" (103) he employs a concept of alchemy, as "The putrefaction of the 'body' of the metal releases the spark of divine light and life which is hidden in it" (Abraham 161). As art is contemplated, the determiners that restrict the soul (or rational capacities) are dissolved, enabling the realization of humankind's potential. The material body, with the sensuous impulse, is redeemed through its reintegration with a mind that has been snatched outside of time. Humankind is able to figuratively ascend to a sense of shared humanity through this ego-death, thus realizing what is true for all time.

The completion of the *putrefactio* has the same effect as Schiller's concept of semblance, that of objectification, and both necessitate a third stage. The artist is able to remove the accumulation of reductive concepts that separate man from his fellow man, i.e. the artist is able to distill his concepts, and then present them through the materials of his time – this is Schiller's concept of semblance. For Schiller, art operates through semblance, meaning that it is a representation, thereby making events and emotions objects that can be studied. Semblance enables individuals to distance themselves from their emotions, and the events of their life, so that they can analyze and educate themselves upon the presentations of the artist, thereby realizing truths for all time (Sharpe 161-62). Both the alchemist and Schiller have, at this stage, produced an object; the alchemist produces the *prima materia*, in which the animating soul has departed and impure material accumulations have been annihilated, leaving behind an object. For Schiller, the artist and audience experience a temporary ego-death, i.e. the body becomes an object, because it is left behind as the viewer contemplates what is true for all time. Following this objectification, there is the task of rejoining the soul with the body, the ability of the object to be animated and energized by the truths that have been realized, namely, an awareness of humankind's shared condition of experiencing conflicting impulses, and a recognition of humankind's potential.

This reintegration is a difficult task, as the recognition of these truths and the ability to continually act on them is confronted by subjectivity and external influences on one hand, and the potential for an overemphasis on reason that can result in passive indifference on another. Schiller encountered this dilemma as a necessary result of conceiving of art as a purificatory object; for Schiller, art allows us to transcend our time, resembling what Kant referred to as the sublime, the elevation of objects to the supersensible level. But we cannot remain outside of time, thus acting as the abstruse philosophers that David Hume so loathed, acting as one oblivious to what actual life requires. We must do what is necessary for our time, within our time, but there is tension as to how to act.

Schiller resolves these points of tension by appropriating the alchemists' *hierogamy*, which he does in "On Grace and Dignity." Grace is the type of beauty in art that enables man to transcend his time. Dignity is the type of beauty that moves man to conform to moral law, so that he is acting within time (Sharpe 156). Schiller assigns the concept of grace a feminine gender, and dignity a masculine gender. In the ideal work of art, the feminine grace is married to the masculine dignity, birthing an ideal artwork that perfectly harmonizes our impulses. This marriage, this harmony, is taken from alchemy. It is the *hierogamy*, taken from what Mircea Eliade termed the *hieros gamos* (161), the sacred marriage. Schiller appropriated the alchemical concept of a union of opposites resulting in an ennobled product. After the soul has left the material body, and both have been purified, they reunite in marriage – the material is resurrected. The resurrected body is the completed philosopher's stone.

Schiller borrowed from alchemy this marriage of opposing forces, with his feminine grace and masculine dignity. In alchemy, mercury is feminine, and sulfur is masculine (Abraham 193; Bartlett 25-26). Feminine grace corresponds with feminine mercury, the spirit that exists outside of time; masculine dignity corresponds with masculine sulfur, the soul that is released from a body upon its death (Abraham 188). The released sulfur/soul is conjoined with the mercury (the transcendent spirit) before re-entering the purified body (188). This chemical wedding births the philosopher's

stone, the ideal self. That Schiller appropriates this chemical wedding, this harmonization, reveals itself in his declaration that "every individual man... carries in disposition and determination a pure ideal man within himself, with whose unalterable unity it is the great task of his existence, throughout all his vicissitudes, to harmonize," and this can be achieved by having the "temporal Man raised to the dignity of ideal Man" (31-2). The ideal man corresponds with the philosopher's stone; as Schiller and the alchemists claim, the temporal man is the soul/sulfur that must be raised to a superior level, that of transcendent reason, corresponding with the spirit/mercury. In alchemy, mercury is variously referred to as Mercurius and Hermes, and "according to most alchemical texts, the chemical wedding… may not take place without the presence of a third mediating principle. This medium of conjunction is Mercurius" (Abraham 127). Thus Schiller's mediating play impulse corresponds with the mediating mercury; the hierogamy, having actions in time informed by rational discoveries, cannot take place without it. In order to continually act on discovered truths, to reintegrate body and soul, humankind must continually play.

Schiller proposes the play impulse, in place of mercury, as the mediating entity that would enable humankind to achieve the completion of the harmonization process. Through the mediating play impulse, the creation and contemplation of art, our conflicting impulses are harmonized, or married (Schiller 74). The play impulse produces beauty, and for Schiller, the beautiful is the moral (76-85). This association of the play impulse with alchemical mercury suggests that the *hierogamy* is the task of the artist, achieved through the exercise of the play impulse, as Schiller calls on the artist to "take his subject matter from the present age, but his form he will borrow from…beyond all time" (51). Form refers to the rational concepts that are true for all time, and they are to be married with, and serve as the design for, the material, or the content, of the contemporary. When Schiller states that man "is to turn everything that is mere form into world, and realize all his potentialities" (63), he employs the alchemical concept of the *hierogamy*, in which the body can now act upon new, rational, concepts. Following the *putrefactio*, the death, the soul rises to the level of the intellect, the body is purified, and the two reunite in this sacred marriage. The result of this marriage was the philosopher's stone; audience members, having contemplated an appropriate artwork, experience this union of their rational capacities with their emotions that have been validated by the active use of reason.

By locating alchemical resources available to Schiller, and tracing the similarities between Schiller's claims and the processes and goals of alchemy, Schiller's abstract proposals are reified and placed within a more tenable context. Schiller's claim that the "inevitable effect of the Beautiful is freedom from passion" (106) is elucidated, as an appropriation of the *preparatio* indicates that Schiller saw the contemplation of art as the alchemical process of removing biases, allowing humankind's rational capacities, or soul, to attain truth for all time. Recognizing the influence of the *putrefactio* offers insight regarding the means of overcoming attachment to a specific time. Understanding Schiller's appropriation of the alchemical *hierogamy* provides a source for the development of his claim that beauty combines and harmonizes our opposing impulses (88), as the claim mirrors the effects of constructing the philosopher's stone. Identifying the similarities between Schiller's claims and the alchemical processes presents a clarified vision of Schiller's methodology for

attaining his concept of the ideal self. To attain this ideal, there must be practice, and art is the laboratory in which humankind can play with abstract concepts, trace them to their effects, and examine emotions as objects. Practice – the creation and contemplation of art – guides humankind to act harmoniously. Thus Schiller's audience is being enjoined to create, to creatively play, leading to the attainment of an aesthetic state. In a rather Romantic sense, the audience is enjoined to play the alchemist.

Works Cited

Abraham, Lyndy. A Dictionary of Alchemical Imagery. Cambridge: Cambridge University Press, 1998. Print.

Bartlett, Robert Allen. Real Alchemy, A Primer of Practical Alchemy. Lake Worth, Florida: Ibis Press, 2009. Print.

Bishop, Paul. Analytical Psychology and German Classical Aesthetics: Goethe, Schiller, and Jung. Volume 1: The Development of the Personality. New York and London: Routledge, 2008. Print.

Eliade, Mircea. The Forge and the Crucible. Chicago: The University of Chicago Press, 1956. Print.

Goethe, Johann Wolfgang von. The Autobiography of Goethe: Truth and Poetry; from My Own Life. 2 vols. Trans. John Oxenford. London: George Bell and Sons, 1897. Print.

Schiller, Friedrich. On the Aesthetic Education of Man. Mineola, New York: Dover Publications, Inc., 2004. Print.

Sharpe, Lesley. "Concerning Aesthetic Education." A Companion to the Works of Friedrich Schiller. Ed. Steven D. Martinson. Rochester, NY: Camden House, 2005. 147-168. Print.

Defining the Natural Rights of Man: An Analysis of Burke, Paine, and Wollstonecraft

Lindsay Kohl
University of North Carolina at Greensboro
Faculty Mentor: Joseph Moore
University of North Carolina at Greensboro

ABSTRACT

Many texts and writing appeared in response to the violence and political upheaval of the French Revolution in the eighteenth century. Edmund Burke, Thomas Paine, and Mary Wollstonecraft were three specific writers of this period that engaged in a dialogue about where the natural rights of man were derived and the limits and responsibilities of governments to their people. Their beliefs were very diverse, but they held much in common as well. Revolution was not always the immediate answer, but at certain critical times in society it could be helpful and even necessary to the protection and preservation of man's natural rights.

As the French Revolution took place in the late eighteenth century, a myriad of texts and writing appeared in response to the violence and political upheaval. Among some of the most notable and compelling writers were Edmund Burke, Thomas Paine, and Mary Wollstonecraft. Their opinions and rhetoric, encompassing everything from the monarchial system to class and gender issues, are still drawn upon today when discussions arise about the origins of modern political thought. Each of them carries a particular set of beliefs about revolution and its proper place and function in society. The diversity of their ideas can be bridged by the theory that all humans are entitled to certain natural rights. However, their individual interpretations concerning the origin of the natural rights of man contrast, and they disagree on the best ways to recognize and protect these rights.

These three writers work to recognize the inadequacies within the political systems of Britain and America as they concerned the natural rights of man. Burke employed a practical approach in writing *Reflections on the Revolution in France* in 1790. He wanted to put his concern for the people of Britain in writing, based on his reaction to the events in France. Paine answered Burke's musings with a text of his own in 1791, *Rights of Man*. His theories centered on a more straightforward radical ideology, and he attacked Burke's support of the English monarchy and defended his own ideas of Republican government. Wollstonecraft's *A Vindication of the Rights of Men*, and *A Vindication of the Rights of Woman*, published in 1790 and 1792, respectively, were a justification and defense of natural human rights, with a unique set of revelations regarding the education

of women and their role in society.

Born in 1729 in Ireland, Edmund Burke was the son of Protestant and Catholic parents. He eventually went to London in 1750 to study law. He was a Whig politician deeply invested in the political life in Britain. He viewed revolution as a kind of obligation to repair some of the grievances present in society, but he drew issue with the violence and anarchy of the French Revolution. He endorsed positive examples such as the Glorious Revolution, which helped England to essentially trade kings while still keeping many accustomed practices of government intact, and the American Revolution, which successfully delivered the Americans from British oppression with significantly less violence than what he believed France was experiencing. Fundamentally, governments were responsible for responding to the practical needs of the people that they governed, but what was occurring in France was a damaging abuse of nature. Rather than moderately amending traditional practices, the people were placing all of their confidence in untested and unproven theories. He saw the French Revolution as chaotic and unpredictable, because the "swinish multitude"[1] was more concerned with their individual liberties than respecting or adhering to custom.

Burke's theories supported belief that the way things are in the present can not be understood by simply taking them at face value. History and precedent are important contributors to society, and they must be taken into consideration in order to better comprehend the needs of the people. For him, provoking the current state of affairs is dangerous. He bitterly asserts: "Massacre, torture, hanging! These are your rights of men!"[2] He was opposed to the brutality and disruptive nature of the French Revolution. His intention was to warn the people of England against being swept up in the same type of passionate, yet catastrophic movement that was corrupting France.

Reflections on the Revolution in France was a provocative text because it took up the subject of the French Revolution and rhetorically exhausted it. Burke was sentimental in his views of the monarchy and reacted to the revolution with gravity and contempt. His political theories are impressive in that his beliefs remained intense and direct through nearly 250 pages of what began simply as a letter. He claims that the hereditary privilege of the monarchy and aristocracy are the foundation for governmental and religious order and believes these principles complement his ideas about inherited natural rights:

[Men] have a right to the acquisitions of their parents; to the nourishmentand improvement of their offspring; to instruction in life, and to consolation in death. Whatever each man can separately do, without trespassing upon others, he has a right to do for himself; and he has a right to a fair portion of all which society, with all its combinations of skill and force, can do in his favour. In this partnership all men have equal rights; but not to equal things.[3]

When examining Burke's view of natural rights in the context of this passage, it is obvious that he favors an idea synonymous with the common proverb: "Give a man a fish and he will eat for a day. Teach a man to fish and he will feed himself for a lifetime." He was horrified by the idea of seizure and had sympathy for those who were deprived of their rank and fortune during the progression of the revolution. For Burke, land equaled freedom. Therefore, the protection of property is also a protection of liberty. Titles of nobility, religious distinctions, and the

1 Edmund Burke, Reflections on the Revolution in France (Oxford: Oxford University Press, 2009), 79.

2 Ibid., 223.

3 Ibid., 59.

preservation of Christianity offered stability in British society. Burke felt this would all be threatened if the ideas of the French Revolution made their way into England.

Burke states that, "by preserving the method of nature in the conduct of the state, in what we improve we are never wholly new; in what we retain we are never wholly obsolete."[4] He felt that adhering to historical precedent is the safest way to ensure the preservation of culture. Improvement is welcome as long as it does not disrupt the natural order of things, and holding true to basic principles of the past does not necessarily mean that the government would be out-dated. This is best demonstrated in his view of the monarchy and privilege:

You will observe, that from Magna Charta to the Declaration of Rights, it has been the uniform policy of our constitution to claim and assert our liberties, as an entailed inheritance derived to us from our forefathers, and to be transmitted to our posterity […] By this means our constitution preserves an unity in so great a diversity of its parts. We have an inheritable crown; an inheritable peerage; an house of commons and a people inheriting privileges, franchises, and liberties, from a long line of ancestors.[5]

Burke saw human beings as being discerning and capable, but also as creatures of habit. He sought to uphold timeless values and structures of government in order to keep a sense of balance and cohesion within society. Natural rights, to Burke, were in every sense prescriptive and determined by estate and inheritance.

Thomas Paine was born in 1737 in Great Britain as the son of a Quaker farmer. After meeting Benjamin Franklin in London, he traveled to America in 1774 and began expressing his strong political views through essays and pamphlets. Paine's writings provide the antithesis to Burke's doctrine. As one of America's most famous revolutionaries, he advocated that, although revolution is often agitated and violent, it is essential to prevent tyranny. Pain saw Burke's ideas as being unfounded, maintaining that, "he does not understand the French revolution."[6] He felt that the minds of the people in France had been long since made up about what needed to happen, and it was just a matter of time before their actions caught up with their thoughts. Paine also stated, "[Burke] is not affected by the reality of distress touching his heart, but by the showy resemblance of it striking his imagination. He pities the plumage, but forgets the dying bird."[7] Paine viewed Burke as being overly concerned with the preservation of established traditions, and blind to the need for reform. His argument against Burke in this sense is valid: Burke believed that government was a basic and natural progression from traditions and institutions, which were not to be manipulated.

The legitamacy of hereditary monarchy is one example of Paine and Burke's differences at the most fundamental level:

Mr. Burke talks about what he calls an hereditary crown, as if it were some production of Nature; or as if, like Time, it had a power to operate, not only independently, but in spite of man; or as if it were a thing or a subject universally consented to. Alas! It has none of those properties, but is the reverse of them all. It is a thing in imagination, the propriety of which is more than doubted, and the legality of which in a few years will be denied.[8]

4 Ibid., 34.

5 Ibid., 33.

6 Thomas Paine, Rights of Man, Common Sense and Other Political Writings (Oxford: Oxford University Press, 2009), 144.

7 Ibid., 102.

8 Ibid., 172-173.

Paine felt that every generation should have the right to establish its own system of government, electing its leaders from the living, not deriving them from the dead. His religious background may well have influenced this idea. The Quaker belief is that each person is responsible for their spiritual growth, rather than reliant on priests or theologians for the understanding or articulation of faith. He felt that families had no right to establish dominance in society, nor did a nation have the right to sanction such families as hereditary leaders.

Government, in Paine's mind, was a necessary evil. It was necessary because a country could not exist without some kind of order and structure, but the smaller and more limited that the government was, the better. Its sole responsibility and duty was to protect the rights of the people, and to uphold the idea of a social contract. He urges England to establish a Republican form of government as the only way to guarantee their citizens' "sacred rights." Such rights included "liberty, property, security, and resistance of oppression."[9] His view that a Republic was superior to a Monarchy meant that people would be free from a system of social castes and hereditary privilege. The flaw of a Monarchy was that it "counteracts nature. It turns the progress of the human faculties upside down." Paine felt that a representative system was more compatible with the "order and immutable laws of nature," and would "meet the reason of man in every part."[10] A representative government would ensure that the whole body of people was represented, and that all of their rights and interests were taken into account. Paine believed that men were born with a prescribed set of natural rights. His ideas about these rights were integral to the formation of ideas regarding civil rights: "Civil distinctions, therefore, [could] only be founded on public utility."[11] Paine believed that the protection of natural rights and the equality and unity of man were a product of creation and should not be designated or infringed upon. Based on his argument, he states that because the government of France was based on elections and representations of the people, then through reason it would stand to be accepted by the citizens of France. This is in contrast to his beliefs about the government in England, which was based on succession and inheritance, and only welcomed because the people were unenlightened.

Paine also differs from Burke greatly in his view of the distribution of wealth. Burke demonstrated his ideas about equality in rights, but not in things. Paine, on the other hand, proposes the redistribution of the national income in order to help the poor. He states, "The first step, therefore, of practical relief, would be to abolish the poor-rates entirely, and in lieu thereof, to make a remission of taxes to the poor of double the amount of the present poor-rates, viz. four millions annually out of the surplus taxes."[12] These early ideas of public welfare and redistributive taxation, and even education for the lower classes, are all factored into Paine's financial improvement plan. His inclusion of these methods of improvement into *Rights of Man* serves to explain, in plain language and figures, his position that natural rights are not just afforded to the aristocracy and upper classes, but to all people. He wanted to have the monarchy abolished, and a Republican form of government installed, in order to best protect those rights.

Mary Wollstonecraft was born in London in 1759 and spent most of her life attempting to gain financial independence as a result of her resentment to the

9 Ibid., 162.

10 Ibid., 235.

11 Ibid., 194.

12 Ibid., 292-293.

practice of primogeniture.[13] In response to Burke's writing and other revolutionary texts, Mary Wollstonecraft penned *A Vindication of the Rights of Men*, and later *A Vindication of the Rights of Woman.* Although the first was more of a direct criticism of Burke, perhaps even a request to "reason together,"[14] the latter was possibly the most preeminent work by a female in the late eighteenth century. She attacks the "wretchedness that [flows] from hereditary honours, riches, and monarchy,"[15] just as Paine does, and disapproves of Burke's justification of the unequal society that promotes the passivity of women by relying on tradition and custom. She criticizes Burke for his sympathy towards aristocratic women in France, while many other mothers who are poor, hungry, and without property of their own were suffering. Notably, Wollstonecraft amplified the basic arguments of Paine and Burke by inserting females into the dialogue, at a time when neither the established values in society nor the most radical egalitarians dared to do so. In one passage, she compares the institution of marriage to the monarchy:

*The **divine right** of husbands, like the divine right of kings, may, it is to be hoped, in this enlightened age, be contested without danger, and, though conviction may not silence many boisterous disputants, yet, when any prevailing prejudice is attacked, the wise will consider, and leave the narrow-minded to rail with thoughtless vehemence at innovation.*[16]

Her ideas about revolution inferred that there were groups, such as women, who were left entirely out of the equation. Because of laws like those of primogeniture, that were in place to protect a family's estate and ensure that it remained within the family, women were left with little or no property rights. Wollstonecraft felt that precedence and customs such as these were no reason to blindly accept laws or a constitutional principle, and that upholding many traditions of the past was tantamount to being irrational, oppressive, and ignorant. This is one area that suggests her conformity with Burke's ideas about land ownership. If land and property ownership meant freedom, and if women were not entitled to land or property, then Wollstonecraft's concern for women's liberties was justified and deserved to be vindicated.

Rights of Woman is sometimes looked upon as an early feminist treatise, but Wollstonecraft's ideas about gender equality were not what we might consider radical today. Burke employs his credibility within the tradition of the landed aristocracy, and Paine uses reason to appeal to the common sense of the public. Wollstonecraft cleverly harnesses the emotions of the middle class and the female voice in order to support her notion that natural rights appeal to men and women alike. Wollstonecraft firmly defends the ideals of Republican womanhood and virtue:

Contending for the rights of woman, my main argument is built on this simple principle, that if she be not prepared by education to become the companion of man, she will stop the progress of knowledge and virtue; for truth must be common to all [… and] if children are to be educated to understand the true principle of patriotism, their mother must be a patriot […] but the education and situation of woman, at present, shuts her out from such investigations.[17]

13 Primogeniture: a rule of inheritance, whether through law or custom, that gave the firstborn (usually male) child entitlement to the entire estate of an ancestor.

14 Mary Wollstonecraft, A Vindication of the Rights of Woman and A Vindication of the Rights of Men (Oxford: Oxford University Press, 2009), 7.

15 Ibid., 77.

16 Ibid., 108

17 Ibid., 66.

While she argues for the education of women in order to enhance their dignity and self-worth, and to make them more valuable members of society, she concedes that only a small number of exceptional women would be suited to a life of independence. This is not because women were not capable, but because they had not been given the opportunity or the equal rights to achieve.

Her Christian view of motherhood promotes companionate marriages, domesticity, and the moral upbringing of children. This is where her argument becomes somewhat ambiguous. Despite her views of marriage as an admirable option for women, she heavily praises modesty and the potential ability of women to deny themselves sexual desires. She calls on them to not be made slaves to their bodies simply because it is their duty as a wife. Wollstonecraft points out that her view of traditional marriage is essentially legal prostitution.[18] Her specific concept of natural rights is rooted in the Christian argument that woman is made as a help-mate for man, not as a subordinate, and by "allowing them to have souls,"[19] it is implied that virtue and happiness are afforded to women as equally as men. Wollstonecraft believes that women are conditioned by society to perform in a weak, falsely-refined, and servile manner; this in turn leads them to be easily manipulated or persuaded into abandoning their sense of virtue.

The arguments and tone of *Rights of Woman* are highly compelling, but there are several rare moments when Wollstonecraft allows that men and women are not fundamentally equal in all aspects of life. First, she notes the differences in the ways that men and women operate on an everyday level: "A man, when he undertakes a journey, has, in general, the end in view; a woman thinks of more of the incidental occurrences, the strange things that may possibly occur on the road; the impression that she may make on her fellow-travellers […]."[20] She also points out that there are obvious differences in physical strength between men and women, and in their physical appearance: "To satisfy this genus of men, women are made systematically voluptuous."[21]

However, these are trivial matters to Wollstonecraft in comparison with the larger picture:

The two sexes mutually corrupt and improve each other. This is believed to be an indisputable truth, extending it to every virtue. Chastity, modesty, public spirit, and all the noble train of virtues, on which social virtue and happiness are built, should be understood and cultivated by all mankind, or they will be cultivated to little effect.[22]

This passage demonstrates her main idea that men and women are not equal in everything, except in morality. Natural rights are as equally important for women as they are for men, and to deny them these rights would be sinful. For Wollstonecraft, it was the duty of society and the government to verify and promote this concept through such means as education for women.

Her ideas about Republican virtue and natural rights extend to promote individual success over the good of society. She favors industry and personal achievement, rather than dependence on others. This idea is prevalent in her ideas about parenting:

Why should the minds of children be warped as they just begin to expand, only to favour the indolence of parents, who insist on a privilege without being willing to pay the price fixed by nature? I have before had occasion to observe, that

18 Ibid., 130.

19 Ibid., 84.

20 Ibid., 130.

21 Ibid., 218.

22 Ibid., 219.

a right always includes a duty, and I think it may, likewise, fairly be inferred, that they forfeit the right, who do not fulfill the duty.[23]

Wollstonecraft did not approve of charity when it promoted idleness. This kind of benefaction simply promotes and maintains inequality while giving the wealthy the appearance and performance of virtue. If the rich give to the poor, there is little incentive for the lower classes to exercise their natural and equal rights of opportunity and advancement. Wollstonecraft advocated for reason, virtue, and knowledge. She believed that reason and feelings should inform each other, virtue should focus on individual happiness, and knowledge was the key to equality within society.

In looking at the texts written in response to the French Revolution by Burke, Paine, and Wollstonecraft, it is evident that there are varying opinions on what man's natural rights are, and whose duty it is to protect them. Edmund Burke's ideas about historical precedent are appealing. Though he is idealistic in his view of the monarchy, he does advocate for reform to be performed in a cautious and moderate way. The past can effectively guide us to make better decisions in the present. For him, natural rights are inherited and formed by society.

Thomas Paine is agreeable in his defense of man being blessed with certain natural rights since creation, but his propositions of public welfare and the common good being the best solution for the improvement of society are disputable. He seems to apply the concept of *noblesse oblige*, where it is the obligation and responsibility of the upper classes to use their money and influence to help those of the lower classes. However, this is contradictory to what he hopes to accomplish because he positions himself in alignment with change and aiding in reform. In reality, his thesis would do no more than perpetuate the chasm between rich and poor and stifle social mobility by making the lower and middle classes dependent on the aristocracy and the government.

Mary Wollstonecraft's ideas about the role of women within society are influential and persuasive, specifically concerning the education of women and her opinion that women and men are morally equal and capable of promoting Republican virtue within society. Allowing that women are both adept and indispensable when it comes to maintaining a family, as well as serving a greater purpose within society, lends itself to a modern, Christian interpretation that motherhood and service can, in fact, coexist. Her focus is expressly on reason and enlightenment. She sums up her idea of natural rights with a causality: if human beings are rational creatures, men and women are both human beings, then women must be entitled to the same natural rights as men.

All three of the writers presented, have a distinct opinion about the necessity and place of revolution within society, and its ability to uphold or undermine their idea of man's natural rights. Burke believed himself to be fairly moderate in his political beliefs; however, his ideas in reference to monarchial tradition, birthrights, and the customs of society serve to classify him as more conservative. Wollstonecraft and Paine are much more libertarian in their desire for equality and natural rights for all. Though one commonality that they all agree upon is that these rights exist, the design in which they are acquired and the ways in which they are exercised and protected was argued over in the eighteenth century, and remains a disputable point today. Being a citizen comes with the duty to protect and defend these liberties. The ways in which a human being chooses

23 Ibid., 238.

to do that enable them to demonstrate their freedom at the most basic level. Burke, Paine, and Wollstonecraft derive meaning by examining different events and circumstances. Their commonality of believing in something is what is most powerful, and it allows them to help facilitate revolution in their own diverse ways. Using the same ideas about natural rights and personal liberties today, we enable ourselves to historicize the present as it relates to the past and draw upon similar arguments in order to gain a deeper understanding of the fundamental principles that make up twenty-first century politics.

Bibliography

Burke, Edmund. Reflections on the Revolution in France. Oxford: Oxford University Press, 2009.

Paine, Thomas. Rights of Man, Common Sense and Other Political Writings. Oxford: Oxford University Press, 2009.

Wollstonecraft, Mary. A Vindication of the Rights of Woman and a Vindication of the Rights of Men. Oxford: Oxford University Press, 2009.

The Greensboro Massacre: A Challenge to Accepted Historical Interpretations

Jason Kops
East Carolina University
Faculty Mentor: Wade Dudley
East Carolina University

ABSTRACT
The Greensboro Massacre, a tragic event in the historical narrative of North Carolina, remains controversial in regards to the root causes and apportionment of culpability. By removing the multiple levels of rhetoric and bias pertaining to the highly charged social groups involved and by analyzing a broader depth of historical documents, the Greensboro Massacre can be examined more objectively. The evidence will demonstrate that the day of the rally did not go as planned according to any participant, and that the communist victims possibly contributed to their own demise.

The killings in Greensboro, North Carolina on November 3, 1979 are mired in controversy arising from the political and emotional atmosphere of the time. Even the common moniker, the Greensboro Massacre, projects bias through its implications of the innocence of those departed and the inhumanity of the aggressors. The level of polarization relating to those groups involved thickens the shroud of bias, attenuating objectivity.

Despite a plethora of documentation on the Communist Workers Party's now infamous "Death to the Klan" march, common misconceptions of this event continue to proliferate. Social bias in North Carolina has tinted the lens of perception, allowing for the easy reception of whichever opinions tend to be loudest. Unfortunately, the most extreme participants voice their arguments at the highest volume. There exist numerous allegations that are not only unsubstantiated but also contradicted by the evidence. Allegedly, Ku Klux Klan (KKK) and affiliated Nazi sympathizers executed a calculated assault on civil rights protestors. Allegedly, both local and federal law enforcement agencies participated in the assault and cover-up. Allegedly, defenseless protesters died fighting for the rights of minorities.

Members of the Communist Workers Party (CWP), the primary proponents and organizers of the "Death to the Klan" march, largely bear responsibility for the tragedy. Negligent of their own safety and without reguard to the safety of others, they incited violence by aggressively provoking the white supremacists. Moreover, members of the CWP demonstrated a pattern of hijacking social causes for the advancement of their own communist agenda. The communists promoted revolution through the exploitation of the victims of social pathologies that they claimed to champion.

Surviving members of the Communist Workers Party have vociferously described the killings as a concerted political assassination by trained paramilitarists. This hyperbolic assertion is undermined by the broader historical evidence that will

be examined. The documentation will support the conclusion that the Klansmen did not conspire to commit murder, and, that while the white supremacy movement increasingly adopted a militant identity throughout the 1970s, the Klansmen did not execute a paramilitary operation on November 3.

The Undisputed Facts

During the late hours of the morning, on November 3, 1979, members of the Communist Workers Party, including prominent members such as Nelson Johnson, Paul and Sally Bermanzohn, and Signe Waller, held a "Death to the Klan" rally in the Morningside Homes housing project in Greensboro, North Carolina. A caravan of cars carrying Klansmen and affiliated Nazi sympathizers drove into the starting point of the march, at the corner of Carver Drive and Everitt Street. Upon arrival and before the rally officially started, violence erupted. A meaningful police presence was completely absent. Lasting only eighty-eight seconds, the riot imparted devastating consequences on the participants and the city of Greensboro. As a direct result, five members of the CWP, James Waller, Sandy Smith, Bill Sampson, Michael Nathan, and Cesar Cauce, were killed. Numerous others were injured and arrested.

A Pattern of Exploitation

Leading to, during, and after the anti-Klan rally, members of the CWP can be characterized as acting recklessly, exacerbating tensions and promoting violence. They pursued their revolutionary political agenda at all costs, negligent to the potential for harm. They attempted to exploit the disenfranchised black community in Greensboro by manipulating racial tensions. However, the Greensboro Massacre was not an isolated example of this behavior. The leading members of the CWP engaged in a pattern of commandeering social causes in order to disseminate their political ideology and recruit soldiers for their revolution.

For many years prior to November 3, 1979, the Greensboro community considered Nelson Johnson, prominent member of the CWP and key organizer of the anti-Klan rally, to be a source of social unrest. A lengthy history of promoting violence and being arrested induced many to view Johnson as "alienated."[1] Johnson first achieved notoriety for his involvement in student protests in Greensboro in 1969. The student council at Dudley High School controversially excluded a student from the election for class president due to his ties to black militancy. Administrators believed this student was under the heavy influence of Nelson Johnson, a campus leader of black militancy at North Carolina A&T.[2] Johnson seemed to take advantage of the backlash to the election at Dudley and organized protests and boycotts at the high school and university. As a result of Johnson's aggressive tactics, casualties mounted: one student was killed and numerous others were injured or arrested. After more than two weeks of unrest, the mayor declared a state of emergency. The National Guard arrived and restored some semblance of peace, but the damage to Greensboro was evident.[3]

Several years later, many future members of the Communist Workers Party first became acquainted at Duke University.

1 Jim Schlosser, "Leaders Are No Strangers Here," Greensboro Record, November 5, 1979.

2 William H. Chafe, Civilities and Civil Rights: Greensboro, North Carolina and the Black Struggle for Freedom (New York: Oxford University Press, 1981), 185.

3 North Carolina State Advisory Committee to the United States Commission on Civil Rights, Trouble in Greensboro: A Report of an Open Meeting Concerning Disturbances at Dudley High School and North Carolina A&T State University (Greensboro, NC: NC Advisory Committee on Civil Rights, 1970), 1-11.

Jim Waller, Cesar Cauce, Mike and Marty Nathan, and Paul and Sally Bermanzohn connected through their experiences at Duke's medical center in Durham. In 1976, communist activists, including the Bermanzohns, pushed for unionization for service workers at Duke. However, infighting amongst rival communist factions derailed the effort. The activists failed to agree on a plan of action for the union drive and prioritized their political agenda over the needs of the employees. The public dispute between the communists involved increasingly radical rhetoric that further discouraged employees from supporting unionization.[4]

Members of the CWP also focused heavily on unionization efforts at several Cone Mills locations in North Carolina. They believed the textile plant floors would serve well as recruiting grounds. The endgame of the communists included revolution and inversion of the status quo, achieved by leading a unionized army.[5] During the late 1970s, they successfully infiltrated several mills and union organizations. Protests were devised, and strikes were coordinated. Friction emerged between the local unions and their parent organizations, and negotiations with plant management regressed.[6] Predictably, the vociferous and radical nature of the communists repelled potential allies and emboldened adversaries. Again, the workers suffered, as their legitimate concerns were eclipsed by the politics of the CWP members.

Moreover, the unionization efforts were more perfidious to the average mill worker than to members of the CWP. The communist organizers, the majority of whom obtained impressive degrees in higher education, made a conscious decision to work at the textile mills. If they lost their job, they had the ability to acquire work elsewhere. On the contrary, the average worker possessed minimal skills and education, with severely limited options for employment. Being terminated from work would bear more devastating consequences for them than for the communists. The members of the CWP failed to take this fact into consideration.

In addition to unionization efforts, the communists with a medical background assisted in the organization of the Brown Lung Association (BLA). Once again, their radical politics created more division than unity. The primary organizers of the BLA were aware of the communist tendencies of the CWP doctors and attempted to mitigate their espousement of political propaganda. They failed. The communist doctors, intent on building the communist party, focused on educating their patients on the connection between capitalism and their health condition. The retired textile workers rejected their political rhetoric and became reluctant to participate in the organization.[7]

Publicity arose surrounding the political ideology of the doctors that tainted the entire BLA campaign. Companies, on the verge of conceding to the BLA's demands, took to the offensive. Because of the communist stigma, the BLA lost all bargaining power. Many of the BLA organizers blamed the communist activists for undermining their legitimate health concerns with Marxist ideas of revolution. Members of the CWP readily parted ways with the BLA in order to focus on the active workforce, a more fruitful source of recruitment than the pool of sick, retired laborers.[8] While the BLA achieved future success in establishing new

4 Bermanzohn, 132-133.

5 Waller, 103-105.

6 William March, "WVO 'Targeted' Cone, Other Mills for Infiltration," Greensboro Daily News, November 5, 1979.

7 Wheaton, 54-55

8 Ibid., 57-58.

safety standards for employees, members of the organization never forgave the CWP. When reports aired that some of the slain victims of November 3 were organizers in the Brown Lung Association, the BLA quickly distanced themselves from the communists.[9]

China Grove, the Greensboro Massacre, and the Aftermath Prior to the November 3 rally, the Communist Workers Party deployed a barrage of media attacks against the Klan in a successful attempt to emasculate them publicly. Earlier in 1979, Klansmen scheduled a showing of the controversial film, Birth of a Nation, at a public library in China Grove, North Carolina. The use of public facilities for the proliferation of racist ideas incensed members of the Communist Workers Party, then known as the Workers Viewpoint Organization.[10] They distributed a flier describing the Klan in the most pejorative and crude of terms. The leaflet overtly encouraged blacks and union workers to violently confront the Klan during their planned event. It also prominently displayed the slogans "Smash the Klan" and "Death to the Klan." Of course, the authors intertwined communist propaganda with their anti-Klan rhetoric.[11]

The confrontation at China Grove on July 8, 1979, while almost devoid of violence, was a major catalyst in the development of tragedy in Greensboro. Believing the First Amendment should be selectively applied, members of the CWP planned to disrupt the Klan activity held at the public facility. In addition to the scheduled Klan event, China Grove housed the largest textile mill in the nation. The communists considered the environment "ripe" for unionization. Defeating the Klan and creating a union stronghold would serve a dual-edged purpose. They supported an organized march to confront the Klan, but disapproved of using explosives, as some locals suggested. Concerns of serving time in jail, not producing casualties, ultimately dissuaded proponents from using explosives.[12]

When protest marchers arrived at the library, the Klansmen realized they were heavily outnumbered, but not out-gunned. Both sides initially refused to back down, but, at the behest of local police, the Klan retreated inside the building. They later left quietly. Joe Grady, a Klan spokesman present at the China Grove event, claimed that the Klansmen were well prepared to establish firing lines, but opted for the more peaceful solution. Even the Klansmen believed that the communists were exploiting the local protesters as "cannon fodder."[13] While members of the CWP actively participated in the protest at China Grove, a local resident, Paul Lucky, primarily directed the response to the Klan.[14] Afterwards, the CWP hijacked the incident as by publicly purporting to be responsible for the success over the Klan.

The communist agitators exploited the widely perceived public defeat of the Klan at China Grove and the Klanmen's subsequent embarrassment. A leaflet distributed by the CWP, once again, encouraged readers to "Smash the Klan," adding that "armed self-defense" and "correct understanding" would be necessary. The CWP publishers claimed responsibility for chasing the Klan from

9 "Claim Disputed," Wilmington Morning Star, November 24, 1980.

10 Sally Bermanzohn, Through Survivors' Eyes: From the Sixties to the Greensboro Massacre (Nashville: Vanderbilt University Press, 2003), 184.

11 Greensboro Police Department, Appendix A.

12 Waller, 184-186.

13 "Klan Rally and Film Protested," Lexington Dispatch, July 9, 1979.

14 Waller, 185-186.

China Grove and insinuated there would be future acts of aggression. The leaflet culminated in an attack on the press for being a tool of the bourgeoisie.[15] "Correct understanding," a subtle and misleading moniker, refers to embracing Marxist ideology and the party line.

The CWP published similar leaflets advertising a rally on November 3, persisting in their assertions that armed conflict was the only method to successfully quell the growing public threat of the KKK. They also continued to utilize the incident at China Grove as an example of their commitment to protecting the people from the overpowering forces of the capitalist aggressors. Issuing an open letter to members of the Klan, the CWP again accused them of being a tool for capitalism and encouraged them to settle their differences through physical confrontation at the rally in Greensboro.[16] They goaded the Klan through television exposure as well.

While the Communist Workers Party distributed leaflets declaring "Death to the Klan," the Klansmen were reluctant to use *death* in their propaganda.[17] Critics may argue for a metaphorical interpretation of the employment of the word *death*. However, an open letter from the CWP to the Klan on October 22, 1979 supports the more literal definition. The intent of the "Death to the Klan" rally is described, in part, as "to organize to physically smash the racist KKK." Again in the letter, the inevitability of the Klan being "smashed physically" is reiterated.[18] The conscious decision by the Klan to exclude the word "death" from their fliers seems to demonstratedat least some level of restraint, which seems completely absent from the rhetoric and actions of the communists.[19]

In addition to a campaign to goad the Klansmen into a violent confrontation, members of the Communist Workers Party engaged in other activities that directly endangered the public. Assuming a confrontation would take place, the CWP placed members of the community at risk by planning a march that traversed several public housing projects. Believing the security would be inadequate at the march, the CWP relied on the community as an auxiliary defense. They produced fliers that solicited residents to defend the march through an armed presence on their porches.[20] Although the CWP failed in its attempt to make soldiers out of unwilling participants, the membership succeeded in converting a peaceful neighborhood into a battlefield.

Many of the decisions made on November 3 by members of the CWP seemed to contribute to the increased potential for disaster. The Klansmen's arrival alone was an act of aggression, but the anti-Klan demonstrators initiated violence by assaulting the caravan of cars. The Klansmen drove to Greensboro with malicious intentions, but they were woefully unprepared for the mass of protesters that violently swarmed them. Contrary to the stipulations of the parade permit, many CWP protesters transported firearms to the rally. Klansmen fired the first shots, but the CWP's use of firearms induced a more forceful response from their counterparts. Many Klansmen intent on fisticuffs scrambled for their firearms after perceiving the communists to be heavily armed.[21]

Curious residents, not affiliated with

15 Greensboro Police Department, Appendix A.

16 Ibid., Appendix B.

17 Workers Viewpoint Organization, "Death to the Klan Flier" in J.A. Armfield Papers.

18 Waller, 203-204.

19 Wheaton, 120-121.

20 Waller, 211.

21 Jack Scism, "Four Die in Klan-Leftist Shootout," Greensboro Daily News, November 4, 1979.

either faction, lined the streets when the confrontation erupted. With plenty of outlets for retreat, members of the Communist Workers Party exchanged gunfire and punches with the Klansmen, increasing the prospect of collateral damage.[22] Jim Waller, prominent member of the CWP and casualty of the rally, supplied at least one protester, untrained in firearms, with a loaded pistol.[23] A mortally wounded Bill Sampson, another member of the CWP, selflessly relinquished his pistol to another injured demonstrator. However, the pistol contained incorrect ammunition, leading to the near-death of its bearer.[24]

After the tragic rally, the Greensboro community did not converge in defense of the protesters. The communists perpetually, and grossly, miscalculated their connection with and support from the local citizenry. Residents were angered by the violence. They insisted, justifiably, that the communist and supremacist outsiders were responsible for the carnage in their streets. Some community leaders regarded the incident as white-on-white violence, unrelated to the civil plight of blacks.[25] Others defended the conduct of police. Despite the heavily charged atmosphere, almost everyone urged for calm and reason to prevail.[26]

The surviving members of the CWP pushed for upheaval, not peace. They engaged in an "Avenge the Murder of the CWP 5" campaign, similar to guerilla advertisement, encouraging violent resistance. Survivors created constant disruptions during court proceedings and held numerous public demonstrations. Due to the belief that the system was rigged, they refused to testify in any trial.[27] Members of the CWP were oblivious to the damage they inflicted. Their radical public displays further marginalized their cause amongst the community. In the absence of survivor testimony, the deceased members of the CWP lacked a personal and emotional presence in court.

The Klan

The embarrassment of the Klansmen at China Grove, North Carolina, where they retreated from a large and hostile crowd, motivated them to attend the "Death to the Klan" march in Greensboro. They assumed that the rally would largely be attended by blacks, not whites, including many of those present at China Grove. This presumption fueled much of the internal Klan rhetoric and agitation.[28] Race played a major role in encouraging the Klansmen to act on their impetus for violence.

In addition to confronting the Klan at China Grove, members of the Communist Workers Party nearly monopolized media exposure, preventing the Klansmen from achieving the press coverage they desperately desired.[29] Certainly, the Klansmen intended on skirmishing with the communists, whom they viewed as the source of their public embarrassment. Despite claims to the contrary, the Klansmen envisioned a "knock-down, drag-out fight," not an exchange of bullets. They expected to brawl against several hundred protesters, mostly large blacks, and believed that the police would be irrelevant in a fistfight. The Klansmen originally decided against

22 Winston Cavin, "Without Warning, the Shooting Started," Greensboro Daily News, November 4, 1979.

23 Wheaton, 129.

24 Ibid., 147.

25 Martha Woodall and Greta Tilley, "Melee Angers Residents," Greensboro Daily News, November 5, 1979.

26 Dwight F. Cunningham, "Residents Pleading Keep Radicals Out," Greensboro Daily News, November 7, 1979.

27 Waller, 268-278

28 Elizabeth Wheaton, Codename GREENKIL: The 1979 Greensboro Killings (Athens, GA: University of Georgia Press, 2009), 110-111.

29 Ibid., 120.

transporting firearms to the rally.[30]

The decision of whether to carry guns became a heated topic of discussion for the Klansmen preparing for the march. All agreed that an effort would be made to produce more noise than the protesters, which would inevitably lead to a physical confrontation. However, conflicting opinions arose regarding firearms. Some Klansmen believed that carrying a firearm would demonstrate their fear of the protesters, unnecessarily emboldening them. The pro-gun camp decidedly won the argument, mainly for concerns about defense. Arguably, uncertainty and fear ultimately compelled the Klansmen to proceed heavily armed.[31]

Additionally, the Klansmen's claims of self-defense bear some credibility, lending doubt to the assertion that they planned a shooting spree. They transported a majority of their firearms in one car's trunk, demonstrating a lack of intent to use them.[32] Upon arrival, the protesters violently swarmed the Klan caravan. The lead car stopped, trapping the subsequent cars in the caravan. Panicked, the Klansmen reacted with an innate and animal instinct.[33]

On November 3, the Klansmen behaved as a disorganized and non-cohesive group, united primarily by their bigotry and propensity for violence. As a collective unit, they acted haphazardly and without foresight. While they are not guilty of all charges made against them, they are culpable on numerous levels for the tragedy that unfolded. The white supremacists deserve more than contempt for their hostile actions and utter disregard for human life. The physical blood, long removed from their hands, continues to metaphorically stain them.

Law Enforcement

Members of law enforcement passively contributed to the Greensboro Massacre, but the claim that they colluded in the killings and participated in a massive cover-up is contradicted by the documentation. The Greensboro Police Department undertook several precautions leading to the anti-Klan rally, well aware of the impetuous nature of the social factions to be in attendance. However, confusion about details and failures of communication plagued the officers assigned to the march.

The Greensboro Police Department (GPD) held a debriefing on the morning of November 3. The officers in charge disseminated several key pieces of information during this meeting that they believed to be true. An unknown number of Klansmen assembled at a location relatively close to the planned route of the march, and at least some of them possessed firearms. The Klansmen planned to heckle the protesters as they marched by hurling eggs and insults. They intended to confront the protesters at the end of the march.

Supervising officers briefed their subordinates on state and local laws that would possibly need to be enforced during the rally. They directly assigned twenty-six personnel to the event. The commanders advised all units to be in their assigned locations no later than eleven-thirty that morning and granted permission to eat lunch beforehand. This decision later haunted them. The parade permit issued designated the starting location as the intersection of Everitt Street and Carver Drive in the Morningside Homes housing project. The permit listed the starting time as noon. When Nelson Johnson, who filed the parade permit, picked up the official

30 Ibid., 111-112.

31 Ibid., 114-115.

32 Ibid., 144.

33 Greensboro Truth and Reconciliation Commission, Greensboro Truth and Reconciliation Commission Report (Greensboro, NC: Greensboro Truth and Reconciliation Commission, 2006), 6.

approval, a police commander requested they meet at Morningside Homes thirty minutes prior to the start of the rally in order to coordinate their actions. Johnson never agreed to the meeting.

Not every police officer assigned to the march took a lunch break before the protest. Some searched for Nelson Johnson prior to the march. They failed to observe any activity at Everitt and Carter, just after ten in the morning, and proceeded to the Windsor Community Center, arriving around ten-thirty. The officers encountered a hostile group of protesters preparing for the march. Having failed to locate Johnson and having further agitated the crowd, the officers decided to pursue a lower profile. They assumed that the protesters would congregate at Windsor and march to the start of the rally. This assumption led to the distraction of many police units from the Morningside Homes area.

At 11:13 AM, Detective Jerry Cooper, the police officer surveilling the caravan of Klansmen, radioed the communications center and informed them that the caravan was mobile and headed towards the rally site. Two minutes later, the radio operator relayed this information to all channels. At this time, many police units were enjoying their lunch, thus tragically out of position. Even worse, key officers involved were intermittently out of radio contact, fettering the coordinating efforts of the police. Cooper first radioed reports of heckling at eleven-twenty-two. During the next minute, he followed with reports of fighting and shots fired. Not yet in position, many officers were helpless to intervene.

With the information available, the Greensboro police should have enacted stronger measures of prevention prior to the Klansmen's arrival at the rally. The act of throwing eggs would constitute assault. Furthermore, any physical act of aggression directed at the protesters would constitute infringement upon their civil right to peacefully assemble. Arguably, the Klansmen could have been arrested on charges of conspiracy as they gathered. Regardless of the potential success for conviction, arrests had the potential to be justified and to avert disaster.

In addition, the police should have taken action to prevent an illegal double standard. In accordance with the agreement in the parade permit, transporting firearms to the rally would have been a violation of the law. The police, aware of the Klansmen's intent on being both armed and in attendance, possessed a foundation to detain the Klansmen and search their vehicles for weapons. At the very least, the police could have searched the Klansmen for eggs.

The police commander who approached Nelson Johnson on November 1 about meeting to coordinate the protest march activities could have been more thorough in establishing a concrete time and place. The officers searching for Nelson Johnson on November 3 claimed to be ignorant of Johnson's appearance, which hindered their efforts. However, as police are often responsible for locating people who do not wish to be located, additional resources could have been utilized in their quest for Johnson.

Distractions foiled the police department in their performance of duties. At no point should officers have been allowed to take a lunch break without relief officers in place. Given the history of animosity between the Klansmen and the protesters, most notably the China Grove incident earlier that year, officers should have maintained a heightened state of attentiveness and performed more diligently. In organizing an operation consisting of twenty-six men, superior officers being outside of radio contact provided for an ineffective response..

Planning and executing a successful demonstration required cooperation between the local police and the protesters.

Arguably, a mutual distrust, deeply rooted in the political ideology of those two groups, sabotaged efforts to coordinate. The communist organizers maintained a distant relationship with the police in regards to the march, and many key officers assigned performed ineffectively in their professional duties.

In their allegations, surviving members of the CWP also implicated the federal government, specifically the Federal Bureau of Investigation (FBI) and Bureau of Alcohol, Tobacco, and Firearms (BATF), in conspiring against them. At the time, the FBI had a well-established reputation of disrupting social movements through extra-legal means. In addition, the FBI and the KKK shared a common enemy, thus an allegiance of sorts, in fighting communism in the years following WWII.

However, the attention of the FBI became heavily focused on the rising influence of white supremacy groups. Starting in the mid-1960s, the FBI pursued an official agenda of aggressively disrupting Klan and Nazi activities, attaining high levels of success towards the end of the decade. Their actions created blowback within the white supremacy community and fostered an increasing hatred and mistrust of the government, perceived to be under the manipulation of communist and Zionist forces. Regarding the killings in Greensboro, the FBI intervened in the aftermath in order to provide security and pacify the volatile atmosphere, not participate in a cover-up.

Unlike the the FBI, the BATF had an undercover agent planted amongst the Klansmen well before the confrontation in Greensboro. Bernard Butkovich infiltrated the white supremacy groups associated with the United Racist Front (URF) in an attempt to intercept illegal firearms. He attended numerous rallies and meetings where Klansmen made preparations for November 3. Agent Butkovich and his superiors failed to adequately communicate with local law enforcement and relay information pertinent to successfully mitigating potential violence.

The performance and effectiveness of the BATF was perhaps hindered by their tunnel-vision. Their desire to procure charges stemming from firearms violations obscured the evident warning signs of impending violence. Despite their failure to serve the greater public good, agents of the BATF actively engaged in tactics designed to disrupt the illegal trafficking amongst white supremacists, not the activities of the communist revolutionaries

As conspiracy theories proliferated after the tragedy, many people failed to notice the irony in accusations of collusion. While the communists maintained that agents of the capitalist government employed the KKK in an effort to crush their Marxist revolution, Klansmen believed that the government was being manipulated by Zionist forces in an attempt to spread communism. The FBI did engage in hostile activities directed towards social movements deemed subversive, including the aforementioned, but they never allied themselves with any radical organization pertaining to the Greensboro Massacre.

Arguably, members of local and federal law enforcement were complicit in tragedy, not conspiracy. While their negligent actions fostered an atmosphere conducive to precludable tragedy, the warring communist and supremacist factions would not be deterred in their pursuit of violent confrontation. Thus far, the members of the Communist Workers Party have attempted to avoid a significant apportionment of blame in the public arena. Nevertheless, as they arguably orchestrated the "Death to the Klan" rally, they arguably orchestrated the violence that ensued.

Conclusion

Throughout the decade prior to the Greensboro Massacre, members of the Communist Workers Party engaged in a

myriad of smaller social movements in order to leverage their political capital. The communists' lack of subtlety and desire for control debilitated the efforts of many organizations in their attempts to redress genuine grievances. The negative consequences of CWP involvement seem to consistently outweighed the benefits of their call to action. Ultimately, the revolutionary agenda of the communists failed; perhaps they were blinded by their own exceptionalism.

As with their other activities, the surviving members of the Communist Workers Party viewed the riot on November 3, 1979 through a distorted lens. They rejected any guilt or responsibility for the tragedy while hurling allegations of conspiracy and assassination. This analysis of historical documents also revealed no evidence of conspiracy among law enforcement, but rather that the members of law enforcement involved performed their duties ineffectively. They acted in a manner bereft of collusion and malice. The Klansmen did arrive in Greensboro with violent intentions. However, they responded to direct incitement from the CWP and, in some unjustifiable capacity, acted as they had in similar situations. The members of the Communist Workers Party did not deserve their fatal consequences, but they certainly set the stage for a high probability for violence and death.

Bibliography

Primary Sources

Bermanzohn, Sally. Through Survivors' Eyes: From the Sixties to the Greensboro Massacre. Nashville: Vanderbilt Press, 2003.

Greensboro (N.C.) Daily News, 1979.

Greensboro Police Department. An Administrative Report of the Anti-Klan Rally, Greensboro, North Carolina, by William E. Swing. Greensboro, NC: Greensboro Police Department, 1979.

Greensboro (N.C.) Record, 1979.

Greensboro Truth and Reconciliation Commission. Greensboro Truth and Reconciliation Commission Report. Greensboro, NC: Greensboro Truth and Reconciliation Commission, 2006.

J.A. Armfield Papers. Greensboro Historical Museum. Greensboro, NC: University of North Carolina Greensboro, 2012. http://library.uncg.edu/dp/crg/collection.aspx?c=69 (accessed on April 22, 2012).

Lexington (N.C.) Dispatch, 1979.

North Carolina State Advisory Committee to the United States Commission on Civil Rights. Trouble in Greensboro: A Report of an Open Meeting Concerning Disturbances at Dudley High School and North Carolina A&T State University. Greensboro, NC: NC Advisory Committee on Civil Rights, 1970.

Waller, Signe. Love and Revolution: a Political Memoir: People's History of the Greensboro Massacre, its Setting and Aftermath. Lanham, MD: Rowman and Littlefield Publishers, 2002.

Wilmington (N.C.) Morning Star, 1980.

Secondary Sources

Chafe, William H. Civilities and Civil Rights: Greensboro, North Carolina and the Black Struggle for Freedom. New York: Oxford University Press, 1981.

Drabble, John. "From White Supremacy to White Power: The FBI COINTELPROWHITE HATE, and the Nazification of the Ku Klux Klan in the 1970s." American Studies 48, no. 3 (Fall, 2007): 49-74.

Wheaton, Elizabeth. Codename GREENKIL: The 1979 Greensboro Killings. Athens, GA: University of Georgia Press, 2008.

Romanticism: New Waves of Imaginative Thinking

Chris Ann Masiello
Elizabeth City State University
Faculty Mentor: Tatiana Tagirova
Elizabeth City State University

ABSTRACT
In this paper I discuss the rebirth of the gothic genre which materialized at the end of the Romantic Period as a mode of escape from the cultural harshness brought by the industrial revolution. This genre represents a new wave in imaginative thinking that integrated mystical elements into poetry to create spine tingling tales. It is for this reason that I chose to analyze Samuel Taylor Coleridge's poems "The Rime of the Ancient Mariner" and "Christabel" as well as Lord Byron's poem "Manfred." All three of them are examples of gothic style of writing that resulted from cruel and reprehensible cultural reality. In the first poem, the strange and unusual supernatural creatures create an atmosphere filled with darkness and obscurity. In the second poem, the main character's struggle against her evil twin parallels doppelganger that existed between two war threatening countries, England and France. In the third poem, Byron incorporates the spirits and spells in order to shed his guilt from his forbidden offense. The single greatest impact of these poems is the ability to transport the reader from their present reality to a preceding time in history that was far less complicated.

As modern industrialization sprang up in England during the eighteenth century, the culture grew extremely cruel to the vast majority of people. It divided them into two classes, the elite with special privileges and the commoners with obligations. The Romantic Period was forged by those who looked at the world in a different light. A writer of that time was often viewed by the majority "as a spokesman of society addressing a cultivated and homogeneous audience and having as his end the conveyance of 'truth' " (Baker, Web). Spun from revolutions and political upheaval, Romantic writers were inspired by dreams of liberty. Their ideas were often viewed by the nobles as a threat to society owing to a new way of thinking. Death by guillotine was their punishment. Yet, it is from this radical ideology and the new perception of the world that the greatest literature emerged.

One of the most influential writers of the Romantic Period is Samuel Taylor Coleridge. He whole heartedly believed in democracy where everyone had the right to be heard. In his poem, "The Rime of the Ancient Mariner," he challenged the Romantics to launch into the supernatural world in their search for freedom. Even though "Christabel" never once employs the term invasion" (Mulvihill, 273), it is based on the threat of the French incursion. Equally, both poems reflect Coleridge's opinion about his culture because they aim to mirror the concerns of his time and to incorporate nature into the people's lives. As a result, he captures the hearts of his readers in his quest for democracy and freedom.

Another influential writer of the Romantic Era is George Gordon, Lord Byron. Lord Byron wrote during his many travels. His poetry "combined the more

popular features of the late-eighteenth-century romanticism: colorful descriptions of exotic nature, disillusioned meditations on the vanity of earthly things, a lyrical exaltation of freedom, and above all, the new hero, handsome and lonely, yet strongly impassioned even for all of his weariness with life" (Byron, 333). Byron's poem "Manfred," is a brilliant example of his style of poetry. It portrays the vibrant beauty of the Swiss Alps. The poem's main character is a very attractive and solitary gentleman who desperately seeks freedom from his earthly transgression. It is for this reason that many people believe that "Manfred" was actually a confession of Byron's own guilt that was brought on by his forbidden love. Byron's personal letters and journals reflect his character's image and bring extraordinary uniqueness into his writings (Gatton, Web). In addition to that, Byron also protests against social injustices and integrates mystical elements to escape the underlying turmoil of the modern industrialization of that time.

During the late eighteenth century, a revolutionary uprising occurred and forced England to enter a new and innovative era known as the Romantic Period. It was a turbulent time of change from an agricultural society to a nation of modern industrialization. New industries replaced the old-fashioned hand labor industry, forcing harsh environments with extended working hours, inadequate pay, and cruel discipline. The "constant threat of inflation and depression" loomed because the English government chose to fund the French and American Revolutionary wars despite public outcries for economic, political, and social reforms (Greenblatt, 2). As a reflection of the harsh English society, writers reached back into Medieval Europe and reintroduced the Gothic genre by incorporating eerie plots, apparitions, and mysterious deaths (Greenblatt, 21). "The Rime of the Ancient Mariner," "Christabel," and "Manfred," are mirror images of the new wave in imaginative thinking that resulted from the notoriously cruel and reprehensible cultural society.

Archaic language integrated throughout Coleridge's poem "The Rime of the Ancient Mariner" was used to escape the present and hold onto the past. As a result of the "global and domestic consequences of the expanding British Empire," the English culture was by in large viewed with great cynicism (Levy, 693). It was for this very reason that many Romantics yearned to revert to a point-in-time that was much simpler and ethically purer. In his poem, Coleridge cleverly incorporated the use of archaic words and spellings as a method to break away from reality and to capture a distinct period in history that was far less complicated. Coleridge chose to incorporate words such as: "gossamers" in place of cob webs, "spectre-bark" instead of ghosts, and "corses" denoting corpses into his poem to enhance its literary mysticism and timeless appeal (Coleridge, 435, 439).

The incorporation of the medieval style of gothic writing is yet another technique that the writer used to escape the complexity of his modern culture. Coleridge's gothic writing style took the reader on a fantasy adventure surrounded by an atmosphere filled with darkness and obscurity. Readers were carried to an extraordinary place adrift at sea with no land in sight. The vessel aboard the open water in Coleridge's poem is important because it symbolized his flight of imagination far away from the realisms of life. It introduced the reader to bizarre and unusual supernatural creatures that symbolized the real cultural dangers that modern industry presented to society. These paranormal creatures derived from the darkest recesses of Coleridge's mind included such monstrosities as "thousands" of grotesque "slimy" sea monsters that "crawl with their legs" as-well-as ghostlike

apparitions (Coleridge, 433, 436). Creatures such as these once again echoed on "contemporary maritime exploration and scientific experimentation," which was highly considered as the "twin dangers of imperialism and science" during the Romantic Period (Levy, 693).

Coleridge also integrated nature and its spiritual affect on one's character. While on their expedition, the Mariner and his fleet encounter a bird known as the Albatross. The Albatross is a symbolic representation of all that is characteristically pure and good. The Albatross followed and encircled the ship for many days begging for food. The Mariner looked upon the Albatross as a savaging vagabond; thus, he decided to eradicate the bird. As Coleridge writes, "With my cross-bow / I shot the Albatross" (81-82). This "pivotal act of slaying the unsuspecting bird reflects the Mariner's failure to achieve universal benevolence. Coleridge may also be suggesting that the Mariner, by having cut himself off from all domestic ties, seems to be incapable of acting kindly toward a "sweet Bird," "a Christian Soul," that "every day for food or play / Came to the Mariner's hollo!" (Levy, 88, 65, 73-74). As the story continues to progress, Coleridge speaks of the repercussions of the Mariners action by saying;

"Ah! Well-a-day! What evil looks
Had I from old and young!
Instead of the cross, the Albatross
About my neck was hung" (434)

The compassion that the Mariner's shipmate exhibited toward the dead bird is undeniably symbolic of the Romantics appreciation and respect for nature and the natural world. It can also be viewed as a moral lesson that is yet to be learned by the Mariner. The Mariner discusses his misconduct by saying,

"And I had done a hellish thing,
And it would work'em woe.
For all averred, I had killed the bird
That made the breeze to blow" (422)

As the story continues to develop, a series of wretched punishments are bestowed upon the Mariner for his indefensible slaughter of the Albatross and for his lack of sorrow and regret. Starting with the initial punishment of thirst, the crew and the Mariner begin to feel the repercussions of disrespecting the life of a once living and breathing animal. As Coleridge states,

"And every tongue, through utter drought
Was withered at the root;
We could not speak, no more than if
We had been choked with soot" (434)

Coleridge further elaborates on the punishment of dehydration by writing,

"Water, water, everywhere,
And all the boards did shrink;
Water, water, everywhere,
Nor any drop to drink" (433)

Yet still another punishment that the Mariner is subjected to is that of isolation and loneliness. The Mariner thought he saw a ship sailing toward his vessel to rescue his suffering crew. However, much to his regret, it was a ghost ship, a ship of imminent demise. Every single one of his fellow crewmen fell to their death leaving the Mariner in total seclusion. Responding to his own feelings, the Mariner says,

"Alone, alone, all, all alone,
Alone on a wide wide sea!
And never a saint took pity on
My soul in agony" (436)

Eventually, the Mariner comes to the realization of the importance of remorse and repentance for the slaying of the Albatross. Only once he learns how

to appreciate and respect God's living creatures, his curse is shed. Coleridge illustrates the Mariners acceptance of all living creatures when he writes,

"And I blessed them unaware:
Sure my kind saint took pity on me,
And I blessed them unaware.
The selfsame moment I could pray;
And from my neck so free
The Albatross fell off, and sank
Like lead into the sea" (437-438).

Relieved from his horrible punishment, the rain begins to fall and his thirst is instantaneously quenched. Coleridge further celebrates the Mariner's new found appreciation of nature and of all of God's creatures when he writes,

"He prayeth best, that loveth best
All things both great and small;
For the dear God who loveth us,
He made and loveth all" (446)

In conclusion to his poem, Coleridge explains that the wedding guest spellbound by the Mariner's story, learns a priceless lesson in moral values that day and departs as "a sadder and a wiser man" (624).
One nuance that directly reflects the deplorable conditions that plagued the modern cities of industrialization is evident in line 138 of Coleridge's poem. Coleridge directly refers to the chimney sweep profession when he states, "We had been choked with soot." This line explicitly alludes to William Blake's poem "The Chimney Sweeper" in which the poet refers to children whose parents could no longer financially afford to care for them and sold them into the merciless labor industry (Blake, 85). These children often worked long laborious hours and were rarely fed or bathed. Time and time again, they developed emotional and medical problems. Sadly, the only true hope these children had to live for was death.

Samuel Taylor Coleridge's poem "Christabel" is another reflection of the new wave in imaginative thinking in which the main character's struggle against her evil twin shows the desire to escape the ominous war with France. With France waging war on England, Coleridge never completed "Christabel" in its entirety. In his poem, the main character named Christabel is a very young and beautiful woman who is seen as a pure and innocent girl. The character named Geraldine is equally young and beautiful. Christabel and her mirroring character Geraldine is a doppelganger. Another doppelganger parallel that should be taken into consideration is the ongoing struggle between England and France. France can be compared to Geraldine because of its persistent threat of war with England. England, on the other hand, can be compared to Christabel because of its peace keeping efforts and desperate struggle to avoid war at all costs.

Lord Byron's poem "Manfred" is yet another direct reflection of the new waves in creative thinking that incorporates metaphysics as a way to escape the harshness of society. A parallel exists between Byron's true life events and his story of "Manfred." In his story, Byron refers to Manfred's distraught feelings over the death of his sister and lover, Astarte. Manfred speaks of their incestuous love when he says, "… though it were / The deadliest sin to love as we have loved" (23-24). Lord Byron opens with a quote from Shakespeare's play "Hamlet," "There are more things in heaven and earth, Horatio, than are dreamt of in your philosophy" (636). The setting of Byron's story takes place in the Swiss Alps, partially in the "Castel of Manfred, and partially in the mountains" (636). The poem begins inside a gallery at the stroke of midnight. Manfred sequentially calls upon seven spirits, "the Air, Mountain, Ocean, Earth, Winds, Night, and Manfred's

guiding Star" and asks forgiveness from his offense (637). The spirits, however, cannot fulfill Manfred's desire of wanting to be absolved from his offense. When the seventh spirit appears, she takes the form of Astarte. Wantonly Manfred reaches out to touch her, but she vanishes. As Manfred drifts asleep, a magic spell filled with gloom and doom is delivered to him in his state of unconsciousness. The magic spell explains to Manfred that he would be tortured by his own disposition and would yearn for death but would be made to live. The following morning, Manfred goes alone to "the Mountain of the Jungfrau" (Byron, 642). It is here, on top of the mountain, Manfred attempts to plunge to his death. Much to Manfred's misfortune, a hunter takes him back to his cabin and gives him a glass of wine. Manfred looks at the glass of wine and sees it as his and Astarte's blood, symbolic representation of their incestuous relationship. As the story develops, Manfred leaves the hunter's cabin and goes to the lower valley in the Alps where he summons a "Beautiful Spirit! With thy hair of light, / And dazzling eyes of glory" (13-14). The beautiful spirit offers to help Manfred, but in turn he must vow to forever be enslaved to her. Manfred refuses to accept the conditions of her proposal by saying,

"I will not swear-Obey! And whom? the spirits / Whose presence I command, and be the slave / Of those who served me-Never!" (157-159). Astarte appears before Manfred once more, and begs for forgiveness, "Say that thou loath'st me not-…" (125). Initially Astarte is silent. And then she replies to Manfred by saying, "Manfred! To-morrow ends thine earthly ills. Farewell!" (151).

The next day, the Abbot of St. Maurice visits Manfred to offer him religious comfort, but Manfred refuses spiritual console. Later that day, upon Manfred's death bed, he breaks down and says to the Abbot, "Give me they hand" (149). It is in Manfred's final moments that he accepts human contact that he shunned throughout his life.

In conclusion, "The Rime of the Ancient Mariner,""Christabel," and "Manfred," are some examples of the new waves in imaginative thinking that resulted from the notoriously cruel and reprehensible cultural society. Old English verbiage was used in the poem "The Rime of the Ancient Mariner" to escape the present and hold onto the past. Historically, the Romantic Period was a terribly stressful time when people longed to return to days that were less demanding. During that time, writers incorporated medieval style of gothic techniques to escape the complexity of modern culture. Fantasy adventures filled with darkness and obscurity were typical. Supernatural creatures incorporated into poems were symbolic of the cultural dangers that modern industry posed. Nature and its spiritual affects on one's character were also implemented. It was in the "Rime of the Ancient Mariner" that the Mariner learned to respect all living creatures and learned a valuable moral lesson in ethics. Deplorable conditions plagued the modern cities of industrialization as illustrated in line 138 of Coleridge's poem "The Rime of the Ancient Mariner. In the poem "Christabel," the main character's struggle against her evil twin was discussed and compared to the desire to escape the ominous war with France. Lord Byron's poem "Manfred" incorporated metaphysics as a way to elude the harshness of society.

Works Cited

Blake, William. "The Chimney Sweeper." The Norton Anthology of World Literature. New York: WW Norton & Company, Inc., (2009): 85. Print.

Baker, Peter S., et al. "English literature." Encyclopædia Britannica. Encyclopædia Britannica Online Academic Edition. Encyclopædia Britannica Inc., 2012. Web. 30 Sep. 2012.

Coleridge, Samuel Taylor "Christabel." The Norton Anthology of English Literature.

New York: WW Norton & Company, Inc., (1962): 449 - 464. Print.

Coleridge, Samuel Taylor "The Rime of the Ancient Mariner." The Norton Anthology of English Literature. New York: WW Norton & Company, Inc., (1962): 430 - 448. Print.

Gatton, John Spalding. "George Gordon (Noel) Byron." British Romantic Prose Writers, 1789-1832: Second Series. Ed. John R. Greenfield. Detroit: Gale Research, 1991. Dictionary of Literary Biography Vol. 110. Literature Resource Center. Web. 1 Oct. 2012

George Gordon, Lord Byron "Manfred." The Norton Anthology of English Literature. New York: WW Norton & Company, Inc., (1962): 635 - 670. Print.

Greenblatt, Stephen, ed. The Romantic Period 1785-1830: Introduction." The Norton Anthology of English Literature. New York: WW Norton & Company, Inc., (1962): 1-25. Print.

Levy, Michelle. "Discovery and the Domestic Affections in Coleridge and Shelley." SEL Studies in English Literature 1500-1900 44.4 (2004): 693-713. Project MUSE. Web. 30 Sep. 2012.

Mulvihill, James. "Like A Lady Of A Far Countrée": Coleridge's "Christabel" And Fear Of Invasion." Papers On Language & Literature 44.3 (2008): 250. MasterFILE Premier. Web. 30 Sept. 2012.

Tyle, Laura B. "Byron, Lord." UXL Encyclopedia of World Biography. Ed. Vol. 2. Detroit: UXL, (2003). 331-333. Gale Virtual Reference Library. Web. 30 Sep. 2012.

Reilley Thayer
University of North Carolina at Pembroke
Faculty Mentor:
Brandon Sanderson
Title of work:
Seasons

Date: 2012
Medium: Woodcut.
Framed dimensions: 54 x 24"

Artist's Statement:

The elements of my work express relationships, the passage of time, reflection and emotional connection. Often the connections are intertwined with the subject matter and I, within the composition, or intended to create a bond with the viewer. While not overt, the symbolism of communication is embodied in simple objects associated with an individual or event. In addition to my meaning, I hope that the viewer will create a narrative beyond my own. Through visual and psychological interaction, I want the viewer to call into question past experience with personal relationships.

Mathematics and Economics

Stochastic Network Susceptibility Models of the 1997 Asian Financial Crisis

Jauhoon Jung
North Carolina School of Science and Mathematics
Faculty Mentor: Daniel J. Teague
North Carolina School of Science and Mathematics

ABSTRACT
This project utilized stochastic network models to predict an economy's susceptibility to the financial contagion that was the Asian financial crisis of 1997. Economic interdependency was based solely on bilateral volumes of trade among eleven national economies that were affected by the crisis, and structural susceptibility was determined by the size of each economy. Two models, one based on imports and the other based on exports, were tested against observed economic trends. The analysis found no statistically significant difference in the correlations of the models against observed exchange rates of national currencies to the US dollar. Further, these high linear correlation coefficients in themselves suggest that stochastic models are practically robust in modeling financial crises. This corroborates the hypothesis that the percolation of the Asian financial crisis, at least in its early stage before IMF intervention on a large scale, was driven primarily through pure network interdependency as opposed to other extraneous factors.

It is widely accepted that the decision to float the Thai baht (THB) from its peg to the United States dollar (USD) in July 1997 was the catalyst to the Asian financial crisis. As a result, the baht became dramatically devalued immediately, and the crisis quickly spread to Thailand's trading partners in the fashion of a financial contagion. Currencies came under speculative attack as investor confidence plummeted; by October, devaluations vis-à-vis the USD averaged 20%-30% in Thailand, Indonesia, Malaysia, and the Philippines (Karunatilleka 10).

Within this paper, it is important to note that the definition of financial contagion is a matter of some debate. Contagion is sometimes defined as "a significant increase in cross-market linkages after a shock to one country." Others neglect cross-market linkages, instead arguing that contagion describes any situation in which a shock is transmitted from one country to another. The latter definition is the one that will be used in this paper. (Forbes and Rigobon 2002).

In this paper, we will attempt to use a stochastic model to track the likelihood of spread of the crisis. Classical susceptible-infected models use differential equations to approximate the expected proportion of a population affected by an infectious disease at a time. Such methods make the assumption that the probabilities that an interaction occurs and that the disease is transmitted are constant and invariant over an entire population. Though they often prove reliable in non-human networks, the fact that some interactions

are more likely than others, particularly in sociological structures, renders them unreliable in many man-made networks. This can be corrected by using a similar set of differential equations that takes into account the degrees of interaction between elements of the group using an adjacency matrix. Financial systems in particular are well-suited to network models.

This investigation had two main purposes. The first was to identify whether the gain of goods or the money used to buy them—that is, imports or exports—provides for a better model in predicting the extent to which each economy is affected by the crisis. The reason behind this dichotomy lies in supply and demand on a macroeconomic scale. Consider the uneven balance of trade between China and the US; China exports to the US much more than the US exports to China. If a financial crisis strikes China, it is harder to produce at internationally competitive prices, which raises the price of final goods in America. Businesses become less profitable, and the American economy suffers. Contrarily, if the US undergoes financial crisis, its national currency is devalued and all the US Dollars present in China lose their value. In this way, the Chinese economy is hurt as well. Thus, in essence, the big question asks whether the economic well-being of producers impacts the well-being of their consumers on an international level, and vice versa.

The second purpose was to determine if, in the early stage of the crisis, the contagion was percolated primarily by network interdependence or by other factors that are thought to have played substantial roles, such as weak fundamentals. As above, the word "interdependence" is based on values of imports and exports from country to country, while the word "contagion" is used colloquially as an infectious disease. The literature review below delves into greater detail concerning the discrepancies in theories behind the percolation of contagion. The economies under consideration were those of Australia, China, Hong Kong, Indonesia, Japan, South Korea, Malaysia, Pakistan, the Philippines, Singapore, and Thailand. Note that remedial financial actions, such as the intervention by the International Monetary Fund (IMF) that is largely thought to be responsible for the aggravation of the crisis in its second stage, are discounted in this investigation.

This paper is structured as follows. Section II provides a brief review of the economic literature concerning the crisis. Section III covers the mathematical methods used to model financial interdependence among the key players. Section IV compares the results of the model against observed economic indicators, while Section V states the conclusions resulting from the analysis.

LITERATURE REVIEW

Economists such as Krugman (1998) claim that risky financial intermediary practices and prices of real assets were the primary forces behind the crisis. Indeed, Radelet and Sachs (1998), propose that a stochastic bubble is created whenever assets are purchased above their intrinsic market value. Over-inflated asset prices are known to have been the cause of the crisis (Karunatilleka 10), implying that a correlation between the flow of assets and the probability that an economy approaches a "crisis state" exists. Glick and Rose (1998) used a bilateral export model as an indicator of interdependence to explain the regional scope of economic crises. An investigation of the Asian financial crisis by Woo et al. (2000) utilizes a logit model, also based on exports. Forbes and Rigobon (2002) incorporated interdependency in their model as well, though instead through cross-market comparisons.

The "stochastic bubble" as described

by Radelet-Sachs supports the use of the trade model that will be used in this paper. Such a model depends on a consistent and coherent definition of a transmission rate, as will be seen in the next section. Glick and Rose acknowledged that discounting for bilateral imports comprises a small imperfection in their model. This is the motivator for the first purpose of this paper: do imports or exports dictate economic interdependency—at least, insofar as determining the transmission rates of a financial contagion?

Woo used discrepancies between his model and observed data to show the unpredictability of crisis from trade data alone. This contradicts the findings of Forbes-Rigobon and to some extent those of Glick-Rose, which said that interdependency sufficiently explained the spread of the crisis. Woo instead proposes that financial panic[1] , along with a host of other external factors, was ultimately responsible. This debate provides the motivation behind the second purpose of this paper: to what extent can trade interdependency explain the spread of the Asian financial crisis, in its early stage?

METHODOLOGY

By definition, the susceptible-infected (SI) model recognizes two states: susceptibility and infection. Though the apparent origin of the contagion was Thailand, it is important to note that the floating of the baht came amidst a system with near-ubiquitous fundamental flaws. However, for the sake of simplicity, it is assumed that the infected state came solely from Thailand.

We now turn to the network theory underlying the analysis. The adjacency matrix of an undirected graph or network is composed of ones to signify the existence of an edge between a pair of vertices, and zeroes to signify the lack thereof. However, our investigation requires that the connectivity between two economies be weighted proportionally to the volume of trade between them. Further, the network must be directed, meaning that each edge has an inward or outward direction with respect to a vertex. The so-called "export model of interconnectivity" states that Economy A is dependent on Economy B to the extent that Economy A exports to Economy B.

In Figure 1, it can be seen that Economy A exports $5 billion in goods to Economy B, and Economy B exports $3 billion in goods to Economy A. Note the flow of trade as shown in the diagram refers purely to the goods being traded rather than the monetary transaction; otherwise, the arrows would be pointing in opposite directions. The idea behind this first model is that an economy is dependent on the money it receives from its transaction with another economy; if the currency value of the importer decreases, then the exporter suffers, and thus the contagion percolates. The adjacency matrix can then be constructed with the value of Economy A's dependency on Economy B under A's column and B's row, while Economy B's dependency on Economy A under B's column and A's row. We assign the first row and column to A and the second row and column to B. Note that a nation's trade dependency on itself is always zero; the export model matrix looks like this:

$$\begin{array}{c} \\ A \\ B \end{array} \begin{array}{c} \begin{array}{cc} A & B \end{array} \\ \begin{bmatrix} 0 & 3 \\ 5 & 0 \end{bmatrix} \end{array}$$

Predictably, the "import model" says that the flow of foreign goods rather than currency indicates dependency on the exporter rather than the importer. The

1 This factor was also cited by Radelet-Sachs (1998).

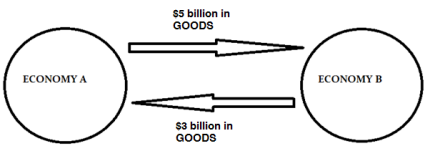
rationale here, as hinted in the introduction, is that businesses import due to comparative advantage: they realize that foreign firms can manufacture some goods at a lower opportunity cost than they can. When a nation's currency is devalued, comparative advantage is often lost, driving up the price of goods, to the detriment of the national economy. With the import model, the matrix is simply the transposition of the export model matrix, so it looks like this[2] :

$$\begin{array}{cc} & \begin{matrix} A & B \end{matrix} \\ \begin{matrix} A \\ B \end{matrix} & \begin{bmatrix} 0 & 5 \\ 3 & 0 \end{bmatrix} \end{array}$$

From here we will adhere to the import model to avoid repetition. Suppose that Economy A carries the contagion. In this case, Economy B has less to worry about in the short run if it carries comparably large imports from the rest of the world. Thus the elements of the matrix must represent proportions of national imports. So if the gross imports of Economy A value $100 billion and Economy B has $200 billion, it would make sense to divide their respective columns by each of them, as shown:

0100520031000200=0.025.030

Figure 1



The transmission rate β of a network is defined as the probability that the infection spreads from one vertex to another. The β factor is typically multiplied to the adjacency matrix, but this is not necessary; by stating that increased trade makes an economy more likely to contract the contagion from its trading partner, this has already been worked into our adjacency matrix. However, a piece is still missing. Weaker economies are generally more susceptible to contagion than stronger economies are. As a simple workaround to this problem, each element of the matrix should be divided by the gross domestic product (GDP) of the economy in question. The β factor then becomes unique to each matrix element, as a trade proportion divided by GDP. If the GDPs of Economy A and Economy B are $400 billion and $500 billion, respectively, the final adjacency matrix of the import model is:

0400.025500.034000500=0.00004.0000750

It is easy to extrapolate both models to more than two countries. Figures 2 and 3 show the adjusted import and export model adjacency matrices for the eleven countries, respectively. Bilateral imports and exports were divided by each nation's total imports and exports as well as its GDP in that year as described above, and then multiplied by a factor of 1013 in order to make the numbers easier to read.[3]

From here, the model becomes a simple application of Euler's method of function approximation. By creating a system of equations xi(t), the probability that economy $1 \leq i \leq 11$ (where i corresponds alphabetically to each of the eleven economies in alphabetical order) lies in the infected state at time t,[4] we use Euler's

2 Though intuition would suggest that the value of imports from A to B is equal to the value of exports from B to A, this often not the case according to the UN Trade Statistics Yearbook.

3 Obviously, this was done so that the numbers would not be negligibly small. Imports and exports were calculated with thousands of USD, while GDP was done with plain USD.

4 Another interpretation of x¬¬i(t) is the "proportion" of economy i that falls under the infected state at time t. This is the more concrete definition on which we will rely

Figure 2

Import	Australia	China	Hong Kon	Indonesia	Japan	Korea, Re	Malaysia	Pakistan	Philippine	Singapore	Thailand
Australia	0.000	2.473	1.086	5.905	4.075	4.172	2.853	1.967	2.557	1.511	1.866
China	5.258	0.000	36.652	3.721	11.580	5.679	2.407	4.730	2.199	3.380	2.959
Hong Kong	1.157	5.061	0.000	0.611	0.737	0.760	2.335	0.382	4.205	3.198	1.054
Indonesia	2.183	1.642	0.810	0.000	4.351	2.669	1.828	1.147	2.040	0.000	0.950
Japan	13.027	21.019	13.405	19.810	0.000	20.919	24.688	10.228	21.838	18.153	30.548
Korea, Republ	2.965	8.933	5.388	5.617	4.567	0.000	5.221	2.670	5.147	3.436	3.495
Malaysia	2.175	1.616	2.185	1.919	3.368	2.000	0.000	5.294	2.471	15.016	4.569
Pakistan	0.185	0.247	0.408	0.440	0.165	0.188	0.063	0.000	0.152	0.000	0.091
Philippines	0.362	0.269	0.473	0.209	1.295	0.387	1.026	0.000	0.000	1.058	0.819
Singapore	3.407	2.594	5.253	6.698	2.097	1.681	13.438	1.624	5.263	0.000	5.879
Thailand	1.379	1.362	1.526	2.552	2.925	0.811	3.327	1.041	1.903	5.463	0.000

Figure 3

Export	Australia	China	Hong Kon	Indonesia	Japan	Korea, Re	Malaysia	Pakistan	Philippine	Singapore	Thailand
Australia*	0.000	0.112	0.764	1.018	0.042	0.262	14.950	2.045	0.858	2.291	0.987
China	0.777	0.000	19.437	1.742	0.125	1.648	23.471	1.776	1.750	2.731	2.195
Hong Kon	0.887	2.212	0.000	1.376	0.145	1.612	56.646	13.073	4.633	8.965	3.430
Indonesia	0.674	0.096	0.315	0.000	0.052	0.463	14.975	2.078	0.760	0.115	1.131
Japan	3.795	2.076	3.711	10.912	0.000	2.284	129.914	9.052	19.588	8.251	11.005
Korea, Re	2.032	0.504	0.934	2.779	0.167	0.000	29.604	4.081	1.978	3.056	1.189
Malaysia	0.580	0.092	0.534	0.940	0.088	0.628	0.000	0.583	3.666	18.120	2.366
Pakistan*	0.049	0.042	0.000	0.106	0.007	0.052	7.927	0.000	0.095	0.217	0.173
Philippine	0.319	0.068	0.674	0.583	0.048	0.276	11.528	0.761	0.000	1.848	0.741
Singapore	0.912	0.252	1.557	3.866	0.119	0.933	196.918	1.350	6.528	0.000	7.925
Thailand	0.458	0.084	0.568	0.697	0.104	0.383	39.384	1.444	4.162	5.712	0.000

method to iterate the equations with respect to a time interval Δt:

$$xit+\Delta t = xit + \Delta t dxidt$$

Let $A_{j,i}$ denote the element in the *j*th row and *i*th column of the adjacency matrix. Recall that $A_{j,i}$ by itself represents a probability that economy *i* is infected by economy *j* given that economy *i* is infected. When this is multiplied by xi, this gives the probability that economy *i* is infected by economy *j* in any circumstance. When summed over all trading partners, we get the probability that economy *i* is infected by any of its trading partners. We then must multiply this by the probability that economy *i* is susceptible, 1-xi_i, to be sure that it already is not infected. This gives an expression for *dxidt*:

$$dxidt = 1 - xit\, jA\, j,ixjt$$

Figure 4

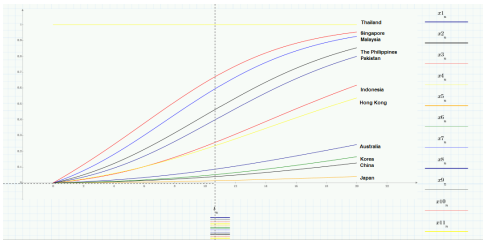
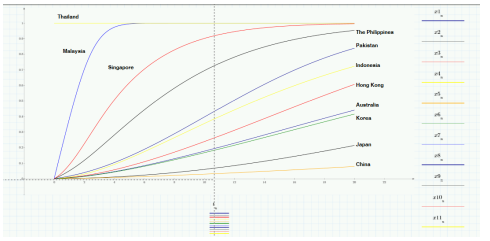


Figure 5



Substituting this expression in the general equation above gives:

in order to interpret our results.

$$xit+\Delta t=xit+\ \Delta t1-xitjAj,ixjt$$

Note that the time unit for t is somewhat arbitrary, as there is no clear way to convert it to a familiar unit of time. Also note that xi can only increase but, as a probability, is bounded between 0 and 1. For this reason all of the functions will approach 1, often resembling a logistic curve (Teague 2012).

Figures 4 and 5 are the respective graphs of xi by the import and export models.

ANALYSIS

The program Mathcad was used to do all the computational work; the matrices were imported into the program and returned graphs (Figures 4 and 5) and values used in the statistical analysis later. The order of infection predicted by the import model as shown in Figure 4 is as follows: Thailand, Singapore, Malaysia, the Philippines, Pakistan, Indonesia, Hong Kong, Australia, Korea, China, and Japan. The order predicted by the export model deviates from the import model slightly, as shown in Figure 5: Thailand, Malaysia, Singapore, the Philippines, Pakistan, Indonesia, Hong Kong, Australia, Korea, Japan, and China.

Simple superposition of the models against actual economic indicators shows a surprising correlation. Figure 6 shows a particularly good case of the import model, Malaysia, while Figure 7 shows a good case of the export model, Japan. The model curve is shown along with the national stock market curve and monthly exchange rates to the USD[5]. Just as we would expect, exchange rates increase and stock indices plunge with the model. In general, exchange rates went back down during the first few months of 1998[6] , so our models capture the appropriate time interval in these graphs. Model graphs for all economies are scaled the same way ($0 < t < 20$); stock market and exchange rates are taken from June to December 1997.

Figure 6

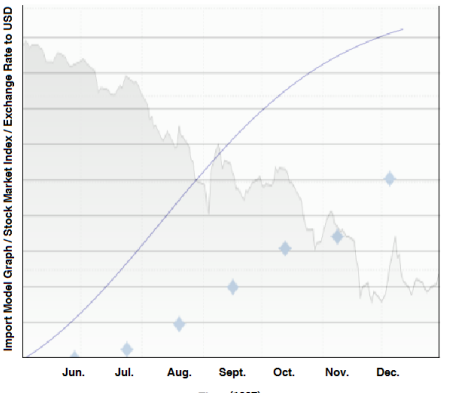


Figure 7

There is a more concrete way to compare the models with exchange rates. Consider the model for an economy over a certain period of time (i.e., that captured by the graphs in Figures 6 and 7). We have two data sets: the exchange rates to the USD for from June to July and the proportions predicted by the model, picked

5 To make a fair comparison across all exchange rates, each exchange rate was transformed into percent change from the June exchange rate.

6 Exchange rates subsequently went back up as the crisis entered its middle stage. However, this does not concern our model.

Figure 8

	Australia	China	Hong Kon	Japan	Korea, Re	Malaysia	Singapore
Import Model	0.957252	0.903624	0.45446	0.989203	0.83179	0.956133	0.902572
Export Model	0.936389	0.904188	0.452651	0.98536	0.770084	0.507908	0.800556

such that they lie between equally spaced time intervals. When we compare them, we should expect some correlation. A direct relationship would be ideal, so we easily find the linear correlation coefficients for each economy. Figure 8 provides a table of these coefficients for both the import and export models; Hong Kong stands as a notable exception in both cases, which will be discussed later.

A difference of means Student-*t* test can be performed to see if there is a statistically significant difference between the correlation coefficients between the import and export models for each individual economy. Following standard procedure for statistical inference, we let the null hypothesis H_0 represent no significant difference in the population means, while the alternate hypothesis H_a represents the contrary. When this is done, the test statistic is $t = .864645$, giving a two-tailed p value of $p = .420453$. Thus we fail to reject the null hypothesis, suggesting no significant difference in the means of correlation coefficients between the import and export models for any national economy tied to the Asian financial crisis.

CONCLUSION

The *t*-test reveals no statistically significant difference in the means between the import and export models of trade. This suggests that they are equally viable models of financial interdependency. While this result makes the importance of foreign currency versus foreign capital goods ambiguous, this in itself may raise deep questions about how we should model financial networks. Thus the first question posed in the introduction is answered.

Overall high correlation coefficients attest to the efficacy of these models, but the case of Hong Kong stands out in its low correlation. This does not seem to make sense, since Hong Kong's stock market falls while its exchange rate remains fairly level. However, both Hong Kong and China operate on a peg to the USD. Even when the Hong Kong dollar experienced speculative attack in August 1997, its value remained stubbornly resilient. The model developed here is not designed to account for any sort of government intervention; indeed, it probably would have reached very different results were it not for the Philippines's and Malaysia's abandonment of their own currency pegs in that year (Karunatilleka 10).

This begs the question: how did both models achieve such high correlation coefficients with China? In 1996, China's GDP, at nearly $1 trillion USD, was the second highest in Asia. Though this was only about a fourth of the highest GDP in Asia (Japan), China's import dependency on the so-called "MIT" economies—Malaysia, Indonesia, and Thailand—were a fraction of Japan's[7]. In short, China's aberrantly high coefficients are coincident with its monetary policy.

In addition, the general order of infection calculated by the model deviates minimally from historical observation. All countries under consideration were affected by the crisis within a very short time period of each other, yet even so the model is

7 China's import dependency ratio on the MIT economies was 0.046, compared to Japan's 0.106. Even more drastically, China's export ratio was 0.0268 against Japan's 0.104.

startlingly accurate in its predictions. Both models predict the closeness of Southeast Asian economies to the crisis, including the "MIT" economies (Krugman 1998). The relatively late impact on Korea's economy, in addition to that of China, was also foreseen by the model.

For such a crude framework, the models perform well in predicting the patterns of the crisis. Given that they rely on trade interdependency, this would imply that the crisis spread in a predictable fashion, disputing the opinion that weak fundamentals played a major role in its early stage. Thus the crisis can be explained by monetary and capital exchange, which can be explained by the formation of speculative bubbles, which can be explained by prices of real assets. This answers the second question brought about at the beginning concerning the percolation of the crisis.

ACKNOWLEDGEMENTS

Thanks to Dr. Dan Teague, for his superb teaching and helpful guidance. Thanks also to Mark Kirollos, Svend Larsen, and Ashwin Monian for their initial assistance in the project.

REFERENCES

1996 International Trade Statistics Yearbook. Vol. I. 2 vols. New York: United Nations, 1997.

Forbes, Kristin J., and Robert Rigobon. "No Contagion, Only Interdependence: Measuring Stock Market Comovements." The Journal of Finance LVII, no. 5 (October 2002): 2223–2261.

Glick, Reuven, and Andrew K. Rose. "Contagion and Trade: Why Are Currency Crises Regional?" National Bureau of Economic Research Working Paper Series No. 6806 (1998). http://www.nber.org/papers/w6806.

Karunatilleka, Eshan. The Asian Economic Crisis. Research Paper. Economic Policy and Statistics Section. House of Commons Library, n.d. http://www.parliament.uk/documents/commons/lib/research/rp99/rp99-014.pdf.

Krugman, Paul. "What Happened to Asia?" The Official Paul Krugman Web Page, January 1998. http://web.mit.edu/krugman/www/DISINTER.html.

Radelet, Steven, and Jeffrey Sachs. "The Onset of the East Asian Financial Crisis." National Bureau of Economic Research Working Paper Series No. 6680 (1998). http://www.nber.org/papers/w6680.

Teague, Dan. "Lecture on Network Infectious Disease Models" presented at the Structure and Dynamics of Modern Networks, North Carolina School of Science and Mathematics, May 2012.

"Trading Economics." Trading Economics, 2012. http://www.tradingeconomics.com/.

"United Nations Commodity Trade Statistics Database." UN Comtrade, 2010. http://comtrade.un.org/db/default.aspx.

Woo, Wing Thye, Patrick D. Carleton, and Brian P. Rosario. "The Unorthodox Origins of the Asian Currency Crisis: Evidence from Logit Estimation." Research Paper, March 2000.

"X-Rates." X-Rates, 2012. http://www.x-rates.com/.

FIGURE CAPTIONS

Fig. 1: Trade Between Economies A and B. Economy A trades goods to Economy B for $5 billion, while Economy B trades goods to Economy A for $3 billion.

Fig. 2: Import Method Adjacency Matrix. Each element represents imports from the country in its column to the country in its row in the year 1996, divided by 1996 national GDP and total imports, and multiplied by a factor of 1013.

Fig. 3: Export Method Adjacency Matrix. Each element represents exports from the country in its row to the country in its column in the year 1996, divided by 1996 national GDP and total imports, and multiplied by a factor of 1013. (Sources: United Nations 1996 International Trade Statistics Yearbook, United Nations Commodity Trade Statistics Database)

Fig. 4: Import Model Graph—Proportion of Economy Infected vs. Time, t. The equations xi represent the economies in alphabetical order: Australia, China, Hong Kong, Indonesia, Japan, Republic of Korea, Malaysia, Pakistan, the Philippines, Singapore, and Thailand. Graphs were generated by iterating Euler's method as described in Section 3.

Fig. 5: Export Model Graph—Proportion of Economy Infected vs. Time, t.

Fig. 6: Malaysian Import Model Graph. The solid curve represents the graph predicted by the import model, the shaded graph is the Malaysian national stock index, and the plotted points are exchange rates to the USD. The key here and in Figure 7 is not necessarily that exchange rates and the import model the same, but that they track together to a uniform scale set up for all graphs, making a vertical scale virtually meaningless.

Fig. 7: Japanese Export Model Graph. The solid curve represents the graph predicted by the import model, the shaded graph is the Japanese national stock index, and the plotted points are exchange rates to the USD. (Sources: X-Rates, Trading Economics)

Fig. 8: Correlation Coefficients of Import and Export Model

An Examination of the Impact of Police Expenditures on Arrest Rates

Ben Shoesmith
with **Chris Klein**
University of North Carolina Wilmington
Faculty Mentor: Julianne Treme
University of North Carolina Wilmington

ABSTRACT
The efficiency of a police force can be seen through its ability to turn expenditures into arrests. Conventional wisdom suggests that the police measure that most consistently reduces crime rates is the arrest rate. Unlike the majority of research involving crime, this paper models arrest rates for violent crime, property crime and murder as a function of police expenditures per capita, crime rates, alcoholic beverage license per capita and unemployment. Panel data estimation and fixed effect models were employed to observe fifty states over the years 1980-2007. Over the 28-year period, police expenditures were significantly linked to each of the three arrest categories. Using time windows of 1980-1989 and 1990-2007, the difference in effects of expenditures on arrests is notable. During the 1980s, the impact of state and local police expenditures was statistically insignificant at the .05 level for all types of arrests. However, during the 1990s and 2000s police expenditures were statistically significant for all arrest rates. The evidence suggests that an increase in police expenditures per capita does positively influence arrest rates.

Introduction

Every community seeks to minimize crime rates. One method used by communities to deter crime is to increase police expenditures. The logic behind this line of thinking is that higher police expenditures will result in a more efficient and effective police force, thereby increasing the probability of arrest and decreasing a criminal's incentive to commit a crime.

Many economists have attempted to identify factors that deter crime. Oddly enough, there has been minimal research that analyzes the productivity of law enforcement agencies in terms of arrest rates as a function of police expenditures.

In a seminal early study, Cameron (1988) found that the impact of police enforcement on crime yielded inconclusive results, though his paper laid the groundwork for the theory linking improved enforcement to lower crime rates. He suggested that when more risk is involved in committing a crime, crime rates fall and noted that the criminal must consider the probability of getting caught, but more importantly, the harshness of the penalty. Criminals must weigh the personal gains of the crime against the odds of being caught and the severity of the potential sentence. In this way, investing in police expenditures can be linked to lower crime rates.

Later studies found that increased enforcement significantly reduces crime rates (Benson et al. 1994; Levitt 1997). Benson et al. (1994) highlighted the fact that even with an increase in police expenditures, which should be a deterrent, funds were not always allocated to the correct place and police incentives were not always taken into account. In a

seminal paper, Donohue and Levitt (2001) presented data that demonstrated a sharp decline in violent crime and murder rates since 1991, and identified incarcerations, police force size, and better police strategies as significant crime deterrents.

Counter to Cameron (1988) and Benson et al. (1994), Darlauf and Nagin (2011) found that the more severe and expensive punishments (longer sentences and capital punishment) did not act as a crime deterrent. They also reported that reallocating police expenditures from imprisonment to police duties, such as patrols, would be a more effective deterrent of crime. Ajilore and Smith (2010) found that over a period in which police expenditures increased, the incidence of crime decreased. Wan et al. (2012) found evidence that increased arrest rates act as a deterrent for future crimes. Their results suggested that a one percent increase in arrests resulted in a 0.1 and 0.19 percent decrease in property and violent crimes, respectively, in the short run. In the long run, the same one percent increase in arrests resulted in 0.14 and 0.3 percent decrease in property and violent crime, respectively.

Hypothesis and Model

We begin our analysis by testing the relationship between crime rates and police expenditures. We consider three different dependent variables: arrest rates for violent crime, murder and property crime. These variables were chosen as the dependent variables because previous literature did not use arrest rates, but rather crime rates, as dependent variables and the variables are important to the whole population as a crime deterrent. An arrest is defined as a person taken into police custody when suspected of committing a crime. The arrest rates were given as the number of arrests made per 100,000 people in a state. The natural logarithm of arrests were used in order for results to be interpreted as percent changes.

Violent crime rates, property crime rates, murder rates, police expenditures per capita, unemployment, alcoholic beverage licenses revenue per capita and lags of each were used as independent variables. Crime rates are the number of crimes recognized (reported and verified to have occurred) by police per 100,000 people in a geographic area, over a period of time. The natural log of the crime rates was also used. Crime rates are expected to have a positive effect on arrest rates, as higher levels of crime result in additional police activity and therefore additional arrests. In the model, crime rates act as a control for different levels of arrest rates across the different types of crimes.

Alcohol and liquor are independent variables in the model and Speer et al. (1998) found that violent crimes increased and were more easily predicted when there was an increase in alcohol availability (density of stores). Alcoholic beverage licenses are used as a proxy in our model for alcohol availability. The variable is defined as the method by which liquor is sold, either through the government or gaining a license and selling as a private company. The expected relationship between arrest rates and alcoholic beverage licenses is positive. Results from Speer et al. (1998) suggests that as the number of alcoholic licenses increase, more alcohol becomes available for purchase, and the number of violent arrests should increase. Since consumers can find alcohol more easily, their consumption increases, and this may result in consumers that are more apt to commit crimes and subsequently leads to more arrests.

Police protection direct expenditures (police expenditures for shortened use in the paper) are defined as money spent on full time and part time police employees, current operations and capital outlay

(which includes construction, equipment, land and existing structures). Marvel and Moody (1996) discovered that crimes had very little effect on the amount of support (funds, personnel, etc.) given to police, but support had a significant impact on crime rates. Expenditures should be inversely related to arrest rates. Theory suggests that an increase in expenditures should increase the technology and manpower police have at their disposal, thus increasing arrest rates. The police expenditures and alcoholic beverage licensure variables were divided by the population of the state to obtain per capita numbers. They were then deflated using a regional Consumer Price Index (CPI) since a state CPI was unavailable and finally, expressed as a natural log. Unemployment is the percentage of people actively looking for work that cannot find a job. Raphael and Winter-Ebmer (2001) found that a decrease in the unemployment rate led to a drop in property crime rates. The sign found in their work is the expected sign in this model as well.

Lags were used for variables in which the effect on the dependent variable could be longer than one year. For instance, it is reasonable to assume that arrest rates may be influenced not only by current police expenditures, but by police expenditures in previous years since the impact of police funds may take several years to significantly impact arrest rates as new programs become more efficient and effective.

This paper uses panel data estimation and year fixed effects to examine state-level data over the time period 1980-2007.[1,2] Year fixed effects control for unseen or unobservable variations in the data. For example, the amount of cocaine present in street sales or in use over time is unable to be measured, but will be captured in the fixed effect. There were a varying number of observations in the data set because of incomplete or missing data, but generally averaged around 1,000 for the whole time period (1980-2007). Over a 28-year period using fifty states, there were a possible 1,400 observations; however, the years 2001 and 2003 did not have complete police expenditure data.

Due to the nature of time series data, autocorrelation was a concern. As is standard in the literature, we used the Durbin-Watson test to test for its presence and our results confirmed that our data did indeed suffer from autocorrelation. We used standard econometric methods to correct for autocorrelation. We also found evidence of heteroskedasticity in our model. Heteroskedasticity was corrected for using White's standard errors. These errors are reported in Tables 1-6. Each independent variable, with the exception of alcoholic beverage license was lagged by one year in the violent crime arrests and property crime arrests models. The murder arrests model has a two-year lagged crime rate variable and a one-year lagged unemployment variable.[3] For example, catching a suspected murderer may take more than a year, so a lag on the murder crime rate will allow for a murderer to be apprehended within this model in a longer time frame.

Regressions were run on two time periods: 1980-2007 and 1990-2007. The years were broken up in this manner so that a distinction could be made between the 1980s and all other years, since new technology was employed by police forces beginning in the 1990s. In both time periods, three regressions were run using violent crime arrests, murder arrests, and property crime arrests as the dependent variables. The results will demonstrate whether there was a significant relationship between police expenditures and arrest rates over the two time periods.

The variables are as follows:

lnVioA = ln Violent Crime Arrest Rate
lnMurdA = ln Murder Arrest Rate
lnPropA = ln Property Crime Arrest Rate
lnVioCR = ln Violent Crime Rate
V1 = ln Violent Crime Rate t-1
lnMurdR = ln Murder Rate
M1 = ln Murder Rate t-1
M2 = ln Murder Rate t-2
lnPropCR = ln Property Crime Rate
P1 = ln Property Crime Rate t-1
lnPolExp = ln Police Expenditures Per Capita
E1= ln Police Expenditures Per Capita t-1
lnABL = ln Alcoholic Beverage License Per Capita
Unemp = Unemployment (expressed as percentage)
U1 = Unemployment t-1 (expressed as percentage)

The following are the models that will be estimated using Ordinary Least Squares (OLS) regression techniques.

Violent Crime Arrest Model:

$$\ln VioA = \beta 0 + \beta 1 \ln VioCR + \beta 2 V1 + \beta 3 \ln PolExp + \beta 4 E1 + \beta 5 \ln ABL + \beta 6 Unemp + \beta 7 U1 + \mu$$

Murder Arrest Model:

$$\ln MurdA = \beta 0 + \beta 1 \ln MurdR + \beta 2 M1 + \beta 3 M2 + \beta 4 \ln PolExp + \beta 5 Unemp + \beta 6 U1 + \mu$$

Property Crime Arrest Model:

$$\ln PropA = \beta 0 + \beta 1 \ln PropCR + \beta 2 P1 + \beta 3 \ln PolExp + \beta 4 E1 + \beta 5 \ln ABT + \beta 6 Unemp + \beta 7 U1 + \mu$$

Results

For the time period, 1980-2007, Tables 1, 2 and 3 represent the regression output for violent crime arrests, murder arrests, and property crime arrests, respectively. For the time period 1990-2007, tables 4, 5 and 6 are outputs for violent crime arrests, murder arrests and property crime arrests. The results for murder arrests will not be discussed in the results section because the interpretations are similar to violent crime arrests and property crime arrests.

Table 1 displays the results for violent crime arrests from 1980-2007. The empirical results suggest that a ten percent increase in violent crime rates (about 46.7 more crimes per 100,000 people) leads to a 7.95 percent increase in arrests (around 14.01 more arrests per 100,000 people). The coefficient on violent crime rate was economically significant. The lag on violent crime results resulted in a much lower coefficient, but was still statistically significant. A ten percent decrease in police expenditures caused a 1.11 percent decrease in arrest rate.[4] The coefficient on alcoholic beverage licenses is notable. The negative sign suggests that an increase in alcoholic licenses leads to a decrease in arrests and counters previous research. We interpret the sign to mean that as the number of licenses increase, people have more choices of places to drink, which decreases crowds from venues as a whole, thereby decreasing the probability of potential fights and crimes in crowded areas. Additionally, a one percentage point increase on the one-year lagged unemployment rate leads to an economically significant 1.05 percent change in violent crime arrests. This result suggests that persistent unemployment leads to an increase in crime as the opportunity cost to commit a crime is lower when people are out of work. The model using murder arrests as the dependent variable can be found in Table 2. This is

Table 1

ln Violent Arrests	Coefficient	Standard Error*	P Value
Intercept	-0.8321	0.1906	<0.0001
ln Violent Crime Rate	0.7950	0.0161	<0.0001
ln Violent Crime $_{t-1}$	0.0634	0.0152	<0.0001
ln Police Expenditures Per Cap	0.1116	0.0236	<0.0001
ln Police Expenditures Per Cap $_{t-1}$	0.0286	0.0233	0.2190
ln Alcoholic Beverage Licenses	-0.0192	0.0070	0.0060
Unemployment Rate	0.0087	0.0061	0.1522
Unemployment Rate $_{t-1}$	0.0105	0.0059	0.0772

N = 1053 R^2 = 0.7446 Durbin-Watson = 1.992

***Whites Standard Errors**

Table 2

ln Murder Arrests	Coefficient	Standard Error*	P Value
Intercept	-0.7218	0.1379	<0.0001
ln Murder Rate	1.0563	0.0208	<0.0001
ln Murder $_{t-1}$	-0.0116	0.0167	0.4891
ln Murder $_{t-1}$	0.0764	0.0155	<0.0001
ln Police Expenditures Per Cap	0.0409	0.0239	0.0872
Unemployment Rate	-0.0144	0.0072	0.0460
Unemployment Rate $_{t-1}$	0.0285	0.0077	0.0002

N = 1056 Adj. R^2 = 0.7791 Durbin-Watson = 2.040

***White's Standard Errors**

for the time period 1980-2007. The results are similar to the results in Table 1 and can be interpreted in a similar manner.[5]

Table 3 uses property crime arrests as the dependent variable. Similar to violent crime arrests, the property crime rate and the lag are significant; however the coefficient on the lag is much smaller than the non-lagged coefficient.[6] Additionally, a ten percent change in police expenditures results in a 1.26 percent change in property crime arrest rates. Property crimes are influenced by unemployment, yet, unlagged unemployment was insignificant. Interestingly, unemployment lagged one year was significant and a one percentage point change in lagged unemployment leads to a 2.62 percent increase in property crime arrests. The change in significance from lagged to base unemployment is likely due to people getting restless after a year without a job (likely because their unemployment benefits or insurance have probably run out) and their need for income will lead them to steal to subsidize their lack of money. The coefficient on alcoholic beverage license is economically significant and statistically significant at the one percent level.

Violent crime arrests, found in Table 4, cover the years 1990-2007. The difference between this group of years and the whole time period is that the lag of violent crime rates is insignificant and alcoholic beverage licenses are no longer statistically significant. The coefficient on police expenditures is larger, so in this case, a ten percent increase in police expenditures (about $8.79 per person in the state) will lead to a 2.03 percent increase in arrest rates (around 3.578 more arrests per 100,000 people). The coefficient may seem small, but is economically significant because there are only 176.25 arrests per 100,000 per year in the average state. The lagged unemployment rate is significant, showing that a one percentage point change in unemployment brings about a 3.78 percent change in arrest rates.[7] This coefficient is more than three times the size

Table 3

ln Property Arrests	Coefficient	Standard Error*	P Value
Intercept	-2.0688	0.3940	<0.0001
ln Property Crime Rate	0.7734	0.0227	<0.0001
ln Property Crime Rate $_{t-1}$	0.1454	0.0335	<0.0001
ln Police Expenditures Per Cap	0.1257	0.0182	<0.0001
ln Police Expenditures Per Cap $_{t-1}$	0.0163	0.0179	0.3645
ln Alcoholic Beverage Licenses Per Cap	-0.0767	0.0079	0.0005
Unemployment Rate	0.0039	0.0051	0.4397
Unemployment Rate $_{t-1}$	0.0262	0.0045	<0.0001

N = 1062 Adj. R^2 = 0.3111 Durbin-Watson = 2.146

***White's Standard Errors**

Table 4

ln Violent Arrests	Coefficient	Standard Error*	P Value
Intercept	-1.0392	0.2701	0.0001
ln Violent Crime Rate	0.7612	0.0228	<0.0001
ln Violent Crime $_{t-1}$	0.0220	0.0193	0.2547
ln Police Expenditures Per Cap	0.2030	0.0355	<0.0001
ln Police Expenditures Per Cap $_{t-1}$	0.0424	0.0342	0.2161
ln Alcoholic Beverage Licenses	-0.0072	0.0085	0.3968
Unemployment Rate	0.0162	0.0124	0.1926
Unemployment Rate $_{t-1}$	0.0378	0.0126	0.0028

N = 570 Adj. R^2 = .7430

***White's Standard Errors**

Table 5

ln Murder Arrests	Coefficient	Standard Error*	P Value
Intercept	-1.0969	0.1703	<0.0001
ln Murder Rate	1.0512	0.0322	<0.0001
ln Murder $_{t-1}$	-0.0114	0.0281	0.6861
ln Murder $_{t-2}$	0.0761	0.0231	0.0010
ln Police Expenditures Per Cap	0.1148	0.0337	0.0007
Unemployment Rate	-0.0233	0.0147	0.1145
Unemployment Rate $_{t-1}$	0.0431	0.0197	0.0293

N = 573 Adj. R^2 = 0.7535

***White's Standard Errors**

of the lagged unemployment coefficient for the time period 1980-2007. Murder arrest's regression for 1990-2007 is found in Table 5. Once again the results can be interpreted nearly the same as violent crime arrests.[8]

The final regression is different from the previous regressions. Table 6 is the output for property crime arrests from the time period 1990-2007. The only variable that is not significant at the ten percent level is the lag on property crime. Property crimes tend to not be as urgent to solve. Therefore police will not search for a property criminal a year after the crime has been committed and they will focus their resources on more violent offenders. Lagged police expenditures have a coefficient that is about one fourth the size of the unlagged police expenditures coefficient. The coefficient on lagged unemployment is larger than unlagged unemployment because, again, people need income after their unemployment insurance has run out and resort to crime to solve their problems.[9] A ten percent increase in alcoholic beverage licenses will lead to a -0.87 percent change in property crime arrests. The equivalent is a $0.16 increase per person in the state will cause arrest rates to drop by 6.19 arrests per 100,000.

Conclusion

Arrest rates impact every member of a population because if arrest rates go up, then the probability that criminals are incarcerated increases. An increase in arrest rates increases the opportunity cost of committing a crime and therefore can be considered a crime deterrent. The empirical results from this study suggest that an increase in police expenditures leads to an economically and statistically significant increase in arrest rates for murders, property crimes, and violent crimes. Future research could use the clearance rate, a measure of police efficiency, as the dependent variable. We found that alcoholic beverage licenses' may lead to a decrease in arrests because people are in situations where crime is less likely to occur since consumers have more venues to purchase and consume alcohol and crowds may be less concentrated as more establishments obtain alcohol and beverage licenses. The coefficient on alcoholic beverage licenses was found to be economically significant for violent crime arrests and property crime arrests. We found that unemployment had the biggest impact on arrest rates, suggesting that the opportunity cost of committing a crime is lowered the longer that people are out of work. Our research also suggests that it is beneficial to lag unemployment rates by at least one year since persistent unemployment increases the amount of leisure time criminals have to commit crimes. During the 1980s police expenditures did not significantly affect arrest rates; however in the 1990s and 2000s police expenditures did statistically and economically affect arrest rates. This supported Marvel and Moody's (1996) results that an increase in funds will increase arrest rates. In conclusion, our research provides empirical justification for investment of public resources in police expenditures in order to increase arrest rates and decrease crime rates.

Table 6

ln Property Arrests	Coefficient	Standard Error*	P Value
Intercept	-2.2367	0.6779	0.0010
ln Property Crime Rate	0.8133	0.0487	<0.0001
ln Property Crime Rate $_{t-1}$	0.0846	0.0530	0.1108
ln Police Expenditures Per Cap	0.1814	0.0301	<0.0001
ln Police Expenditures Per Cap $_{t-1}$	0.0475	0.0274	0.0828
ln Alcoholic Beverage Licenses Per Cap	-0.0865	0.0120	<0.0001
Unemployment Rate	-0.0227	0.0127	0.0746
Unemployment Rate $_{t-1}$	0.0357	0.0114	0.0017

N = 579 Adj. R^2 = 0.2594

***White's Standard Errors**

Table 7: Key Descriptive Statistics

Dependent Variable	N	Mean	Standard Deviation
Violent Crime Arrests	1079	176.25	87.67
Murder Arrests	1088	5.51	3.56
Property Crime Arrests	1088	711.76	235.28

Independent Variable	N	Mean	Standard Deviation
Violent Crime Rate	1300	466.99	239.37
Murder Rate	1300	6.26	3.55
Property Crime Rate	1300	4212.14	1153.42
Police Expenditures Per Cap	1300	87.89	36.32
Unemployment	1300	5.78	2.01
Alcoholic Beverage License Per Cap	1355	1.61	1.69

FOOTNOTES

[1] The District of Columbia was not included because of its outlier numbers of crime.

[2] State fixed effects were found to be insignificant and were not used in the model.

[3] The outcome of the F Tests are reported in footnotes below.

[4] 1980-2007 Violent Crime Arrests- H0: Police Expenditures = T-1=0; HA: not--- F Test= 2.845 >2.303. Reject null hypothesis, at least one of the coefficients is not 0.

[5] 1980-2007 Murder Arrests- H0: Murder Rate = T-1 = T-2 =0; HA: not --- F Test= 984.67>2.084. Reject null hypothesis, at least one of the coefficients is not 0.

[6] 1980-2007 Property Crime Arrests- H0 Police Expenditures =T-1 =0; HA: not --- F Test= 6.97>2.303. Reject null hypothesis, at least one of the coefficients is not 0. Property Crime Arrests- H0: Unemployment = T-1 =0; HA: not--- F Test= 5.54>2.303. Reject null hypothesis, at least one of the coefficients is not 0.

[7] 1990-2007 Violent Crime Arrests- H0: Violent Crime Rate = T-1 =0; HA: not--- F Test= 512.41>2.303. Reject null hypothesis, at least one of the coefficients is not 0. Violent Crime Arrests- H0: Police Expenditures = T-1 =0; HA: not--- F Test= 14.87>2.303. Reject null hypothesis, at least one of the coefficients is not 0. Violent Crime Arrests- H0: Unemployment = T-1 =0; HA: not--- F Test= 6.13>2.303. Reject null hypothesis, at least one of the coefficients is not 0.

[8] 1990-2007 Murder Arrests- H0: Murder Rate = T-1 = T-2 =0; HA: not--- F Test=436.18>2.084. Reject null hypothesis, at least one of the coefficients is not 0.

[9] 1990-2007 Property Crime Arrests- H0: Property Crime Rate = T-1 =0; HA: not--- F Test=31.57>2.303. Reject null hypothesis, at least one of the coefficients is not 0.

References

Ajilore, Olugbenga, and John Smith. "Ethnic fragmentation and police spending." Applied Economic Letters. (2010): 329-332. Web. 31 Aug. 2012. <http://www.tandfonline.com/doi/full/10.1080/13504851003670650>.

Benson, Bruce, Iljoong Kim, and David Rasmussen. "Estimating Deterrence Effects: A Public Choice Perspective on the Economics of Crime Literature." Southern Economic Journal. 61.1 (1994): 161-168. Web. 26 Feb. 2012. <http://www.jstor.org/stable/1060137>.

Cameron, Samuel. "The Economics of Crime Deterrence: A Survey of Theory and Evidence." Kyklos: International Review for Social Sciences. 41.2 (1988): 301-323. Web. 26 Feb. 2012. <http://onlinelibrary.wiley.com/doi/10.1111/j.1467-6435.1988.tb02311.x/abstract>.

"Consumer Price Index (CPI)." U.S. Bureau of Labor Statistics. Division of Consumer Prices and Price Indexes. Web. 11 Nov. 2011. <http://www.bls.gov/cpi/>.

Darlauf, Steven, and Daniel Nagin. "Imprisonment and crime." Criminology & Public Policy. 10.1 (2011): 13-54. Web. 31 Aug. 2012. <http://onlinelibrary.wiley.com/doi/10.1111/j.1745-9133.2010.00680.x/full>.

"Easy Access to FBI Arrest Statistics." Office of Juvenile Justice and Delinquency Prevention. Web. 9 Nov. 2011. <http://www.ojjdp.gov/ojstatbb/ezaucr/asp/ucr_display.asp>.

"Expenditure and Employment Data for the Criminal Justice System Resource Guide." National Archive of Criminal Justice Data. The Regents of the University of Michigan, 2010. Web. 19 Dec 2012. <http://www.icpsr.umich.edu/icpsrweb/content/NACJD/guides/eecjs.html>.

"GDP and Personal Income." Bureau of Economic Analysis. US Department of Commerce. Web. 12 Nov. 2011. <http://www.bea.gov/iTable/iTable.cfm?reqid=70&step=1&isuri=1&acrdn=1>.

Levitt, Steven. "Using Electoral Cycles in Police Hiring to Estimate the Effect of Police on Crime." American Economic Review. 87.3 (1997): 270-290. Web. 3 Sep. 2012. <http://socserv.socsci.mcmaster.ca/bjerk/PublicPapers/Levitt97.pdf>.

Levitt, Steven, and John Donohue. "The Impact of Legalized Abortion on Crime." Quarterly Journal of Economics. 116.2 (2001): 379-420. Web. 26 Feb. 2012.

"Local Area Unemployment Statistics Home Page." U.S. Bureau of Labor Statistics. Web. 18 Oct. 2011. <http://www.bls.gov/lau/>.

Marvell, Thomas, and Carlisle Moody. "Specification Problems, Police Levels, and Crime Rates." Criminology. 34.4 (1996): 609-646. Web. 26 Aug. 2012. <http://onlinelibrary.wiley.com/doi/10.1111/j.1745-9125.1996.tb01221.x/abstract>.

PI. "The United States and the Development of DNA Data Banks." Privacy International.

Privacy International, 20 Feb 2006. Web. 26 Feb 2012. <https://www.privacyinternational.org/article/united-states-and-development-dna-data-banks>.

"Property Crime." Wikipedia, the Free Encyclopedia. Web. 25 Nov. 2011. <http://en.wikipedia.org/wiki/Property_crime>.

Raphael, Steven, and Rudolf Winter-Ebmer. "Identifying the Effect of Unemployment on Crime." Journal of Law and Economics. 44.1 (2001): 259-283. Web. 26 Aug. 2012. <http://www.jstor.org/stable/10.1086/320275>.

Speer, Paul, D.M. Gorman, Erich Labouvie, and Mark Ontkush. "Violent Crime and Alcohol Availability: Relationships in an Urban Communitity." Journal of Public Health Policy. 19.3 (1998): 303-318. Web. 26 Aug. 2012. <http://www.jstor.org/stable/3343538>.

"State-by-state and National Crime Estimates by Year(s)." Uniform Crime Reporting Statistics. Web. 3 Nov. 2011. <http://ucrdatatool.gov/Search/Crime/State/StatebyState.cfm>.

"Violent Crime." Wikipedia, the Free Encyclopedia. Web. 25 Nov. 2011. <http://en.wikipedia.org/wiki/Violent_offence>.

Wan, Wai-Yin, Steve Moffatt, Craig Jones, and Don Weatherburn. "The effect of arrest and imprisonment on crime." Crime and Justice Bulletin. 158 (2012): 1-20. Web. 31 Aug. 2012. <http://www.cso.nsw.gov.au/lawlink/bocsar/ll_bocsar.nsf/vwFiles/cjb158.pdf/$file/cjb158.pdf>.

Divergence Measurements of Empty Parking Spaces

Wen Tang
Fayetteville State University
Faculty Mentor: Yufang Bao
Fayetteville State University

ABSTRACT
An interesting topic to researchers in image processing is using computer vision techniques to design an automatic parking space recognition system to serve as a guide for vehicles entering a parking lot. This current research project aims to reduce the time a driver needs to find a parking space in a busy area where empty parking spaces are in high demand. In this paper, we employ information theory to deal with the problems of recognizing the status of a parking space (empty or occupied) from a parking lot image. Three different entropies are used to define the divergence measures between a parking space and a vacant parking space, so that the decision of whether a parking space has been occupied by a vehicle or not can be measured using the calculated information distance. The Matlab program is used to simulate the system for recognizing the status of parking spaces. Our research shows that the Tsallis divergence achieves the best performance in recognizing the parking spaces that are occupied by objects among the three entropies.

1 INTRODUCTION

1.1 Research Background

Fast population growth and progressively active traffic have made it a problem to find empty parking spaces in modern cities. While vehicles bring us convenience for shopping and traveling, they become a burden when we don't need to use them. Finding an empty parking space could be time consuming; especially, the time wasted in searching for a vacant parking space in the parking lot of a busy area during rush hour could bring drivers headaches. Perhaps all drivers have the experience of circulating in the parking area without finding an available parking space. This can lead to a traffic jam at the gate of a parking lot. One of the reasons for the low efficiency of finding a parking space could be lack of up-to-date information about the parking lot. This difficulty might be alleviated if some information could be displayed on an LED screen at the gate of the parking area to give clues to incoming drivers. The existing (VPSD) systems serve this purpose by using parking lot entrance/exit sensors[1]; however, the drivers still need to find the exact vacant space. Thus, researchers are interested in designing an automatic system to locate vacant parking spaces to help the drivers.

There are two different approaches that researchers are interested in to design an efficient parking guide program. One is to attach a hardware sensor to a vehicle to communicate with the control center in the parking lot, accompanied by attaching a navigational system at the vehicle's end[6]. The other method is what researchers are often more interested in, namely, to apply mathematical knowledge to find useful information contained in an image taken

from a surveillance camera overseeing the parking area[1-5]. This is preferable because sensors are not only expensive, but also inconvenient to be installed.

In this paper, we use the mathematical knowledge to develop an algorithm for recognizing the vacant parking spaces by analyzing a parking lot image. We apply three information divergence measurements to identify vacant parking spaces—the mutual information, the Jensen Rényi divergence, and the Jensen Tsallis divergence. We have concluded that Jensen Tsallis divergence is the most efficient in recognizing the empty parking space.

1.2 Related Work

In recent years, various image processing methods have been applied to identify parking space occupancy. In the previous studies, Hsu et al.[2] proposed using the ratio of the total edge length of an object inside a parking space and the perimeter of the parking space. The edges of objects in a gray valued image are detected by using the Laplacian operator that uses the second derivative. The drawback with this method is that only boundary information is used, which could lead to misclassification. Later, Bong et al.[3] proposed to calculate the difference between the target parking area and the empty parking area using a color image to obtain a residue image, and the Sobel edge detection operator was used to detect any edges presented in the residue image in order to locate an object. The problem with this method is that it requires that the two images are obtained in the same identical condition and are completely registered. In 2008, T. Fabian[4] proposed a geometry model to detect an empty parking space. The two dimensional (2D) coordinates of a parking space image are transformed into the three dimensional (3D) spatial coordinates so that a box-car can be used to simulate a car of generic class to judge the status of a parking space. This requires removing lens distortion and shadow. Meanwhile, Yamada et al.[5] identified the image segments according to gray value levels, and computed the ratio of the densities of a vacant parking space and an occupied parking space to analyze the distribution of a segmented area in order to detect the presence of a vehicle. N. True[1] began with human-labeling the parking space regions, then generating the color histograms by converting the color images from RGB to L*a*b* space. The k-nearest neighbor classifier was used to recognize the status of the parking space.

So far, there are drawbacks with each system. In some situations, it becomes very complicated to recognize an empty parking space, especially when taking into account the illumination condition and the angulated camera in the parking lot. Even a small object such as a water bottle could become an obstacle for an algorithm to recognize the empty parking space, not to mention the problems with shadows and object obtrusions.

2 THEORETICAL FRAMEWORKS

In this research, we adopt three different entropies, namely, Shannon entropy, Rényi entropy and Tsallis entropy to define distances between every parking space and a selected empty road to determine whether a specific parking space has been occupied or not. In this section, we will introduce the definition of the three entropies and their corresponding definitions of divergence.

2.1 Definition of Entropy

Entropy is the measure of uncertainty in physical systems, or the average amount of information that may be gained from observing the information source. Shannon entropy[7] is the fundamental entropy of the information theory, but it only shows the average amount of information.

Later, the Rényi entropy[8], [9] and the Tasllis entropy[10] were introduced. Both generalized the Shannon entropy by using a parameter to control the sensitivity of the entropy in representing different probability distributions[7].

2.1.1 Shannon Entropy

Definition 1: For a discrete random variable X defined on the probability space $(\Omega, \mathcal{F}, P)$ with probability distribution $P(x_i) = P(X = x_i)$, $x_i \in \Omega$, $x_i \in \Omega$, where I is an index set, the Claude Shannon entropy [7], [17] is defined as

$$H_P(P(x)) = -\sum_{i \in I} P(X = x_i) \ln P(X = x_i) \tag{2.1.1-1}$$

with "$\ln$" denoting the natural logarithm.

Definition 2: For a continuous random variable with a probability density function $p(x)$, $x \in R^d$, the Claude Shannon entropy is defined as

$$H_P(P(x)) = -\int_{R^d} p(x) \ln p(x)\, dx \tag{2.1.1-2}$$

2.1.2 Rényi Entropy

Definition 3: For a discrete random variable X defined on the probability space $(\Omega, \mathcal{F}, P)$ with probability distribution $P(x_i) = P(X = x_i)$, $x_i \in \Omega$, $i \in I$, and for $\alpha \in (0, 2]$, $\alpha \neq 1$, the Rényi entropy [8], [9], [17] is defined as

$$R^\alpha(P(x)) = \frac{1}{1-\alpha} \ln\left(\sum_{i \in I} P^\alpha(x_i)\right) \tag{2.1.2-1}$$

Definition 4: For a continuous random variable X with a probability density function $p(x)$, $x \in R^d$, the Rényi entropy is defined as

$$R^\alpha(P(x)) = \frac{1}{1-\alpha} \ln\left(\int_{R^d} p^\alpha(x) dx\right) \tag{2.1.2-2}$$

where $\alpha \in (0, 2]$, $\alpha \neq 1$.

We can see that, when $\alpha \to 1$, the Rényi entropy degenerates to the Shannon entropy [11], [17].

2.1.3 Tsallis Entropy

Definition 5: For a discrete random variable X defined on the probability space $(\Omega, \mathcal{F}, P)$ with probability distribution $P(x_i) = P(X = x_i)$, $x_i \in \Omega$, $i \in I$, and for $\alpha \in (0, 2]$, $\alpha \neq 1$, the Tsallis entropy [10], [17] is defined as

$$T^\alpha(P(x)) = \frac{1}{(\alpha - 1)\left(1 - \sum_{i \in I} P^\alpha(x_i)\right)} \tag{2.1.3-1}$$

Definition 6: For a continuous random variable X with a probability density function $p(x)$, $x \in R^d$, the Tsallis entropy is defined as

$$T^\alpha(P(x)) = \frac{1}{(\alpha - 1)\left(1 - \int_{R^d} p^\alpha(x) dx\right)} \tag{2.1.3-2}$$

where $\alpha \in (0, 2]$, $\alpha \neq 1$.

The advantage of both the Tsallis entropy and the Rényi entropy is that the probability (or the probability density) is modulated by a factor α; In addition, the Tsallis entropy can be more sensitive to the parameter α.

2.1.4 A Specific Example for Rényi Entropy and Tsallis Entropy

Here we provide an example to illustrate the property of Rényi entropy and Tsallis entropy using the Bernoulli distribution. The Bernoulli distribution describes the distribution of a random variable

X with probability $P(X = 0) = p$, and $P(X = 1) = 1 - p \quad (0 \le p \le 1)$. Fig. 2.1.4-1 demonstrates the Rényi entropy for different $\alpha \in (0, 2]$ for Bernoulli distribution. As we can see, when $\alpha = 1$ the Rényi entropy is equal to the Shannon entropy. Fig. 2.1.4-2 shows the Tsallis entropy for different $\alpha \in (0, 2]$ for Bernoulli distributions. It can be seen from both figures that Tsallis entropy has the most significant variation for different α. Rényi entropies almost reach the same values as the Tsallis entropy when the probability p = 0.5.

Figure 2.1.4-1

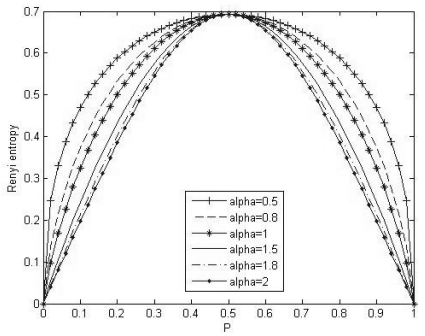
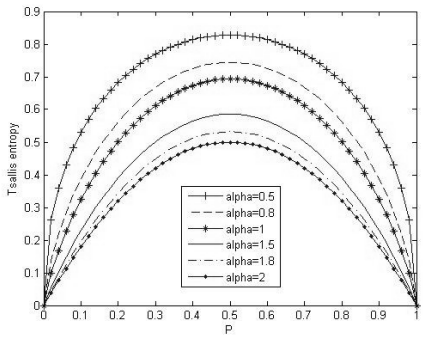


Figure 2.1.4-2



In information theory, the divergence represents the difference between the probability distributions of signals/images intensities. The larger the divergence is, the more diverse the distributions of the signals/image intensities are. The general measurement is call Kullback-Leibler[12] (KL) divergence. The mutual information is a KL divergence that has been widely used as a measurement of the information that one object contains about the other object. In the late 1980s, the Jensen Rényi divergence [13-14, 19] was introduced based on the Rényi entropy to measure the difference between various probability distributions. Hence the divergence among various distributions can be obtained using the Jensen Rényi divergence with different weights to reduce the influence on the divergence caused by the shapes of the probability distributions.

The Jensen Tsallis divergence [10], [15], [18] is defined using the Tsallis Entropy by the combination of Jensen-information and the Tsallis entropy. It has the same attributes with the Jensen Rényi divergence.

2.2.1Kullback-Leibler Divergence

Kullback-Leibler divergence is a distance between two probability density functions f and g. It also can be written as where f and g are probability density functions of two random variables X and Y. The Kullback-Leibler [12] divergence is defined as

$$K(f|g) = \int_s f(s)\log\left(\frac{f(s)}{g(s)}\right)ds \tag{2.2.1}$$

2.2.2 Mutual Information

The mutual information is shown in Fig. 2.2.2, and can be defined as follows.

Definition 7: For two discrete random variables X, Y defined on the probability space $(\Omega, \mathcal{F}, P)$ with probability distribution $P_X(x_i) = P(X = x_i)$, $x_i \in \Omega$, $i \in I$, and $H(p)$ represents the Shannon entropy, the mutual information [7] between X and Y is defined as

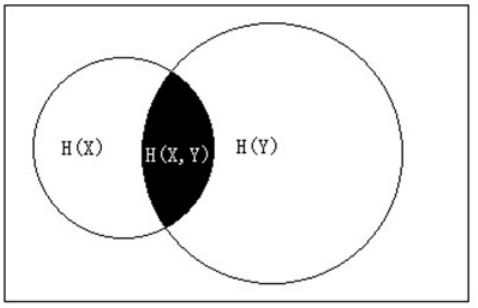
$$I(X;Y) = H(X) + H(Y) - H(X,Y) = H(X) - H(X|Y) = H(Y) - H(Y|X) \tag{2.2.2-1}$$

It can be further expressed as

$$I(X;Y) = \sum_{x,y} P(X=x, Y=y) \ln \frac{P(X=x, Y=y)}{P(X=x)P(Y=y)}$$

(2.2.2-2)

Figure 2.2.2



2.2.3 Jensen Rényi Divergence

The Jensen Rényi divergence is a generalization of Jensen-information. It is used to measure the divergence between distributions. It invokes a weighted combination of several distributions modulated by an exponential parameter.

Definition 8: For a set of probability distributions $\{P_i(x)\}_{i=1,\dots,n}$, Jensen Rényi (JR) divergence [13-14] is defined as

$$JR_\alpha^{\{w_i\}_{i=1,\dots,n}}(\{P_i(x)\}_{i=1,\dots,n}) = R^\alpha\left(\sum_{i=1}^{n} w_i P_i(x)\right) - \sum_{i=1}^{n} R^\alpha(P_i(x))w_i$$

(2.2.3-1)

Where $H^\alpha(P)$ is Rényi entropy, and $W = (w_1, w_2, \dots, w_n)$ is a weight vector such that $\sum_i w_i = 1, \mathbf{0} \le w_i \in R$ and $0 < \alpha < 2$. When $w_i = P_X(x)$, $P_i(x) = P_{(Y|X)(y|x)}$, the JR divergence measures the dependency between two resources, which can be viewed as a direct extension of mutual information.

$$I_R^\alpha(X;Y) = JR_\alpha^{\{P_X(x)\}_{i=1,\dots,n}}\left(\left\{P_{(Y|X)(y|x)}\right\}_{i=1,\dots,n}\right) = R^\alpha(Y) - R^\alpha(Y|X)$$

(2.2.3-2)

where $R^\alpha(P(x))$ is Rényi entropy.

2.2.4 Jensen Tsaills Divergence

The Jensen Tsallis divergence [10], [15], [18] is another generalization of Jensen-information, and can be defined as

Definition 9: For a set of probability distributions $\{P_i(x)\}_{i=1,\dots,n}$, Jensen Tsaills (JT) divergence [10], [15], [18] is defined as

$$JT_\alpha^{\{w_i\}_{i=1,\dots,n}}(\{P_i(x)\}_{i=1,\dots,n}) = T^\alpha\left(\sum_{i=1}^{n} w_i P_i(x)\right) - \sum_{i=1}^{n} T^\alpha(P_i(x))w_i$$

(2.2.4-1)

where $H^\alpha(P)$ is Tsallis entropy, and $W = (w_1, w_2, \dots, w_n)$ is a weight vector such that $\sum_i w_i = 1, \quad \mathbf{0} \le w_i \in R$ and $0 < \alpha < 2$, . When $w_i = P_X(x)$, $P_i(x) = P_{(Y|X)(y|x)}$, the JT divergence measures the dependency between two resources, which can also be viewed as a direct extension of mutual information.

$$I_T^\alpha(X;Y) = JT_\alpha^{\{P_X(x)\}_{i=1,\dots,n}}\left(\left\{P_{(Y|X)(y|x)}\right\}_{i=1,\dots,n}\right) = T^\alpha(Y) - T^\alpha(Y|X)$$

(2.2.4-2)

where $T^\alpha(P(x))$ is Tsallis entropy.

2.3 The Properties of Divergence

We can obtain the basic properties of JR divergence as following:

1. We have JR divergence $= R^\alpha\left(\sum_{i=1}^{n} w_i P_i(x)\right) - \sum_{i=1}^{n} R^\alpha(P_i(x))w_i \geqslant \mathbf{0}$ because $R^\alpha\left(\sum_{i=1}^{n} w_i P_i(x)\right) \geq \sum_{i=1}^{n} R^\alpha(P_i(x))w_i$

This has resulted from the Jensen inequity, namely

$$f\left(\sum_{i=1}^{n} p_i x_i\right) \geq \sum_{i=1}^{n} p_i f(x_i) \tag{2.3-1}$$

where $\sum_i p_i = 1$, $p_i \geq 0$ when the function f is a positive concave downward function, for example, $f(x) = \ln(x)$. The minimum value is reached if and only if $P_1(x) = P_2(x) = \cdots = P_N(x)$. $I_R^{\alpha}(X;Y)$ can reach the minimum value 0 when the random variables X and Y are independent.

2. The upper-bound of the JR divergence [14] can be reached when the second term of the JR divergence equals to 0, that is, when $P_i(x)$ is a degenerated distribution with $[P_i(x) = P(X = x]_i) = 1$.

3. When w_i is uniformly weighted (i.e. $w_i = \frac{1}{N}$), the maximum value can be reached and we have the following inequality,

JR divergence $\leq R^{\alpha}(W) \leq \log n$

The JT divergence has the minimum value zero when all the random variables are independent. If all the probability distributions are degenerated, the maximum value of the JT divergence will be reached, the JT divergence also can satisfy the following inequality [15]

$0 \leq$ JT divergence $\leq \log n$.

3 VACANT PARKING SPACE DETECTION

3.1 Image Preprocessing

In recent years, mutual information, JR divergence have been JT divergence are used in image processing to measure the difference between the distributions of two different objects in classification and in image registration. For instance, He et al. [11] used JR divergence to register several images into the same orientation.

In order to use the divergence defined above to detect a vacant parking space, segments of each parking lot are located first. An empty road segment is a good choice to be used to compare with all other parking spaces. This is not only because it has the same ground texture as an empty parking space, but also because the intensity distributions of the two ground images can be viewed as independent.

3.1.1 Segmenting a Parking Lot

Typically, a parking area is marked with lines to divide each parking space. Lines in white, yellow, or blue colors are used for different purposes. With a color image, different color pixels can be selected as land mark points to represent the information of different parking lines and road.

The images of different objects can be segmented by converting the RGB color information into the L*a*b* color space, shown in Fig. 3.1.1-1. The selected three primary colors are used to calculate the Euclidean distance between the landmark colors and all pixels in L*a*b* color space. Three color groups can be separated as in Fig. 3.1.1-2. After the parking lines are identified, the coordinates of four vertices of every parking space are located, which can be used to locate the inside content of each parking space. Then, in order to obtain an empty road information, edge detect technique is use to detect the ground texture in the parking area. Canny detector, a gradient based algorithm, is used in the edge detection.

Figure 3.1.1-1

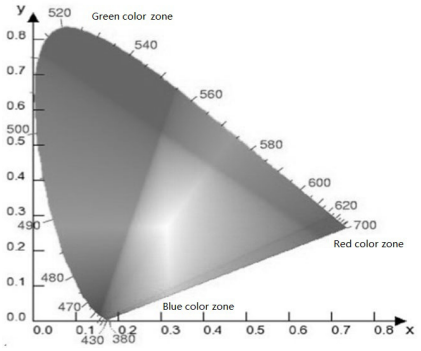
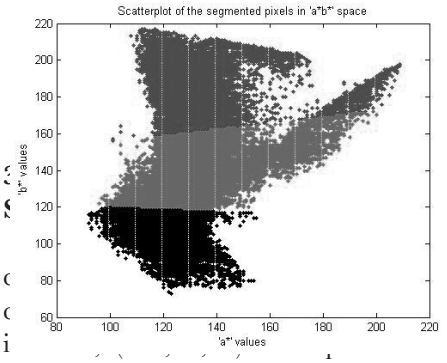


Figure 3.1.1-2



color. Hence a three dimensional matrix can be obtained when a color image is input. The data contain red, green and blue values in all the three channels sequentially. In order to achieve the best recognition performance, we use all data from the three dimensional matrix for analysis.

In this section, we will describe the method used to generate the histogram to approximate the probability distribution of a parking space. The histogram of a segment of road can be generated similarly.

In applications, the probability distribution is typically approximated by the empirical probability. In terms of an image with intensities ranging from 0~255, it is the relative frequency of image intensities in various ranges called bins. The number of bins is decided by the bin width L , and is defined as

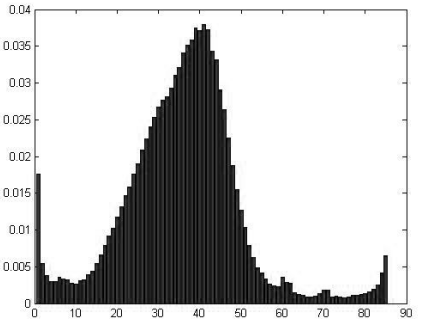
$$M = ceil\left(\frac{256}{L}\right) \tag{3.2.1.2-1}$$

Here ceil is a function that rounds up to the smallest integer that is greater than $\frac{256}{L}$. The length of the bin width decides the approximate of the probability distribution. In our case, we choose bin width = 3, and 85 bins in total were used in generating our histogram. Let (x_i, x_{i+1}) , $i = 0, \dots, M-1$ represent the i th bin. The empirical probability is calculated as

$$P_i = \frac{number\ of\ pixel\ value\ fall\ in\ (x_i, x_{i+1})}{number\ of\ total\ pixels} \tag{3.2.1.2-2}$$

A histogram is a graphical representation to show the empirical probability distribution. Since our input is a color image, we collected all the RGB components in the data to generate the histogram in our processing. This processing allows us to use all the intensity information provided in a color image to generate a histogram that best approximates the probability distribution. In Fig. 3.2.1-2, a histogram for a parking space is shown.

Figure 3.2.1.2



3.3 The Divergence measure of Parking Spaces

The divergence measure generated by Shannon entropy is referred to as the mutual information, while the divergence measures generated by Renyi entropy and Tsallis entropy are referred to as the Jensen-Renyi divergence and Jensen-Tsallis divergence. In the following sections, we will introduce how to calculate the three different divergences.

3.3.1 Mutual Information Calculation

To calculate the mutual information, we employ the location dependent pixel values inside each bin. Since different locations of pixels may have the same values which located in one image or in different images, we use the gray values of the pixels in image Y that are located at the same location of image X to calculate the conditional probability, which is used to calculate the conditional entropy in the mutual information.

$$I(X;Y) = H(Y) - H(Y|X)$$

Here, Y is the target image, the unknown parking space. X is the baseline image, the empty road segment. Mutual information is non-negative. It reaches its minimum value 0, when the random variables X, Y are statistically independent.

3.3.2 Calculation of Jensen-divergence

Since the JR divergence becomes the Renyi mutual information, $I_R^{\alpha}(X;Y)$ when $w_i = P_X(x)$, $P_i(x) = P_{(Y|X)(y|x)}$. The Renyi mutual information is obtained when the Rényi entropy is used to replace the Shannon entropy in the mutual information formula. The same method is also used to calculate the conditional distribution for the Rényi mutual information. In the same way, Tsallis mutual information can be calculated.

3.3.3 Relationship between Mutual Information and Rényi Divergence

The continuous version of the JR divergence between random variables X and Y is Rényi mutual divergence that can be written as

$$RD_{\alpha}(X,Y) = \frac{1}{1-\alpha}\ln\left(\int h^{\alpha}(x,y)[f(x)g(y)]^{1-\alpha}dxdy\right)$$

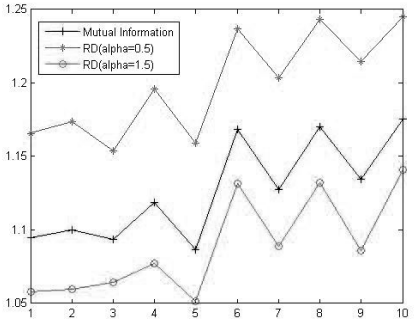
The selection of α allows the divergence be enlarged or reduced. It allows Rényi entropy and Tsallis entropy to provide measurements that are better to distinguish the similarity between random variables than the mutual information. As a generalization of Shannon entropy, the relationship between Rényi Divergence (RD) and the mutual information is shown in the following [19].

Theorem 1. Case 1: Given $0 < \alpha < 1$,
$RD_{\alpha}(X,Y) \geq I(X,Y)$
Case 2: Given $1 < \alpha \leq 2$,
$RD_{\alpha}(X,Y) \leq I(X,Y)$

In Fig. 3.3.3 are shown two examples that compare the mutual information with the JR divergence, at $\alpha = 1.5$ and $\alpha = 0.5$. The1024 possible positive values of the random variables, are respectively generated by a random function.

It can be seen that, Rényi divergence at $\alpha \in (0,1)$ takes the greatest value when comparing with the values of mutual information and Rényi divergence at $\alpha \in (1,2]$. Rényi divergence at $\alpha \in (1,2]$ is much less than the values of mutual information. This is consistent with the theorem mentioned above. Moreover, the rate of change for Rényi divergence at $\alpha \in (0,1)$ is the greatest among the three cases.

Figure 3.3.3



3.4 Vacant Parking Space Identification

In our algorithm, the divergence measures are used as the criteria to separate vacant spaces from occupied spaces. We will focus on using the divergence to identify the vacant parking space.

First, we need to use the empty parking area to find the optimal value of the exponent parameter to reach the maximum divergence possible between the empty parking space and the parking space that has objects inside. The algorithm is used as follows for JR and JD separately

$$\alpha = \arg max_{\alpha}\left(JR_{\alpha}^{\{P_X(x)\}_{i=1,\dots,n}}\left(\left\{P_{(Y|X)}(y|x)\right\}_{i=1,\dots,n}\right)\right) \tag{3.4-1}$$

$$\alpha = \arg max_{\alpha}\left(JT_{\alpha}^{\{P_X(x)\}_{i=1,\dots,n}}\left(\left\{P_{(Y|X)}(y|x)\right\}_{i=1,\dots,n}\right)\right) \tag{3.4-2}$$

where X , Y are two random variables, $P_{(Y|X)}(y|x)$ is the conditional distribution and the $P_X(x)$ is the marginal distribution. The distance, which is utilized to calculate the similarity between the unknown parking space and the empty parking space, is defined as

$$distance = D_i^1 - \max(D_1^0, D_2^0, \dots, D_N^0) \tag{3.4-3}$$

where D stands for one of the three divergences that we have discussed. D_i^1 represents the divergence between the i th target parking space and the empty road, $i = 1, \dots, n$; D_j^0 represents the divergence between the j th original empty parking space and the empty road, and $j = 1, \dots, N$. The parking space status is defined as a function

$$\chi_i = \begin{cases} 0 & if\ distance \leq 0 \\ 1 & if\ distance > 0 \end{cases} \tag{3.4-4}$$

where 0 indicates that the unknown parking space is similar to the empty parking space, thus it is an empty parking space; oppositely, 1 indicates it is an occupied parking space. Fig. 3.4 is a flow chart that illustrates our parking space identification algorithm.

Figure 3.4

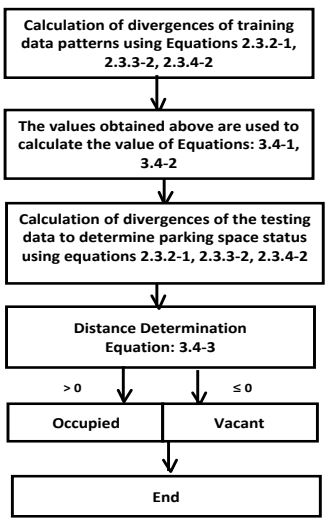


Figure 4.1-1

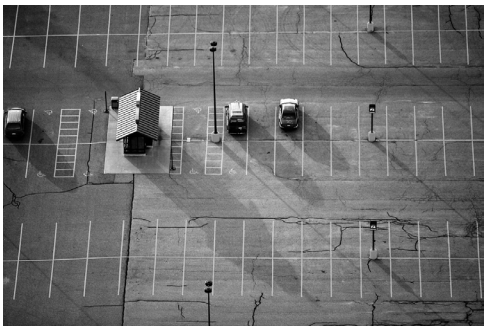


Figure 4.1-2

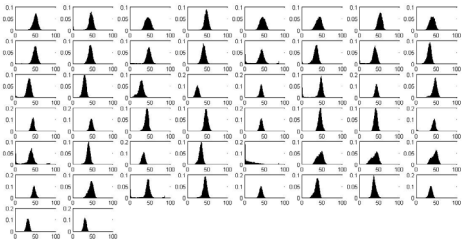
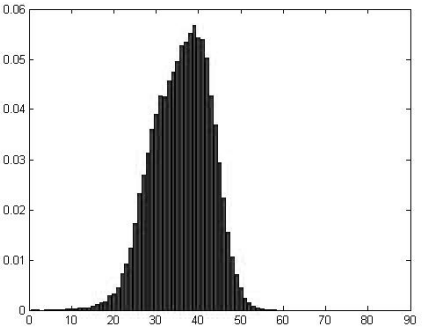


Figure 4.1-3



4. EXPERIMENTAL RESULTS

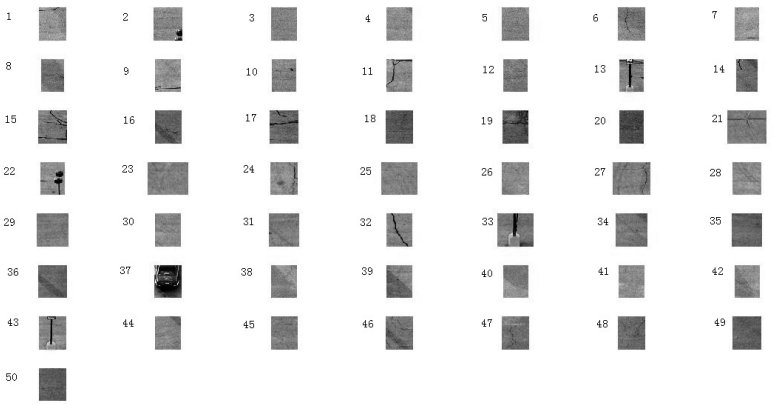
4.1 Training Data

First, we select the α value in order to reach the maximum divergence. The initial value of the factor α of Renyi entropy and Tsallis entropy is set to 1.5.We use an empty parking area image as shown in Fig. 4.1-1 as a training image to decide how large the divergence is to yield a maximum value of the divergence between two empty parking spaces. We use this to decide the value of α .

When $0 < \alpha < 1$, the values of Jensen Rényi divergence and the Jensen Tsallis divergence are greater than the Shannon mutual information. The divergences grow when the value of α decreases. Thus we tried to decrease the value of α . Then it was decreased to 0.5, which is good enough for us in this example.

After the training image is preprocessed, one empty road segment and 50 parking spaces are located, which yield 51 corresponding probability distributions (Fig. 4.1-2 and Fig. 4.1-3 above). Note

Figure 4.1-4



that some shapes of the distributions are different from others because of obstacles or vehicles in this parking space.

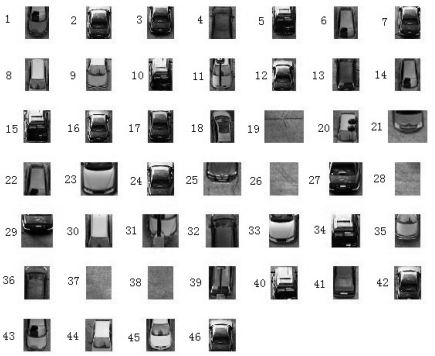
The three divergences between each parking space and the empty road are shown in Tables 4.1-1, 4.1-2, and 4.1-3 (see Appendix). From the tables, we can observe that No. 37 parking space has the maximum value among these divergences in each table. It corresponds to a black car in this parking lot. The training dataset allows us to set the threshold for Shannon mutual information as 0.4986; the thresholds for Rényi mutual information and Tsallis mutual information are chosen as 0.5181 and 7.4350 separately.

4.2 Testing Data

After setting the parameter and the boundary values, we start testing our algorithm. The testing image is a busy parking lot with few empty

Figure 4.2-1

Figure 4.2-2



parking spaces as shown in Fig. 4.2-1. 46 parking spaces recognized from the image. Note that the color marks (not shown) chosen at the beginning for segmentation decides the number of parking spaces that can be recognized. Among the 46 recognized parking spaces, 5 empty parking spaces are detected according to Fig. 4.2-2.

The three divergences of each pair of target parking space and the baseline parking space are calculated. All the values that are less than the threshold have been picked out and traced to locate the empty parking space. According to the Table 4.2-1 to 4.2-3, 35 parking spaces are picked out as unoccupied by Shannon mutual information. The Rényi mutual information picked out all parking spaces which used as testing data, whereas, the Tsallis mutual information detected all the

Figure 4.2-3

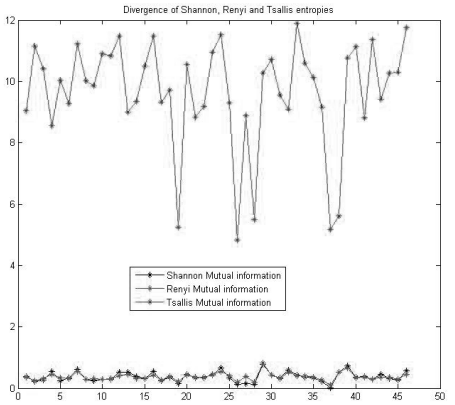
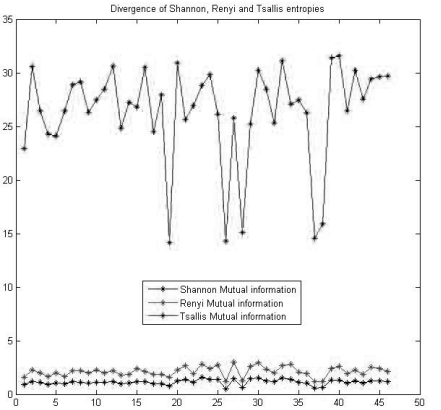


Figure 5-1



empty parking spaces.

The experimental result has shown that the α of the Tsallis divergence makes the solutions much more sensitive, and it maximized the divergence between two objects. The distance between the maximum and the minimum of Tsallis divergence is 7.0614, whereas the distances of Renyi divergence and Shannon divergence are respectively 0.7205 and 0.7736.

5. ADDITIONAL IMPROVEMENTS

One drawback with using information theory as a measurement is that it is an average measure of the difference of histograms and thus the location feature of an image is lost. Hence, we have improved our approach of finding the divergence by using subdivision information of a parking space. To compensate, we further divide every parking space into four sub-segments to partially keep the location information. Each sub-segment of the target image is compared with the corresponding sub-segment of the basic image. The measuring divergence of the two images will be the sum of all the divergences.

This method is applied to finding the mutual information, Rényi divergence, and Tsallis. After using the training images, we set the thresholds for all the three divergences. The threshold for Shannon divergence is 0.8816, the threshold for Rényi divergence is 1.9686 and the threshold for Tsallis divergence is 22.2576. And the factor α is still set as 0.5. After running our improved algorithm on the testing image, it resulted in 46 parking spaces being recognized. Comparing the Fig. 5-1 and Fig. 4.2-3, we can see that the distances of Rényi divergence and Shannon divergence are significantly larger than those calculated in section 4. This is also true for the Tsallis divergence's distance.

The results from the different divergences have shown that the correct recognition rate using Shannon divergence has increased from 0 to 5; and 5 empty parking spaces have been recognized using Rényi divergence.

6. CONCLUSIONS

In this paper, we use three entropies (Shannon entropy, Rényi entropy and Tsallis entropy) to propose divergence measurements (the mutual information, the Jensen Rényi divergence, and the Jensen Tsallis divergence) of the similarity between two parking space images. Our experiment has shown the strongest performance from

the Tsallis mutual information because its corresponding divergence value is greatly enlarged by α.This has made it a better measurement for us to find all the occupied parking spaces. Furthermore, we have improved our algorithm by subdividing the image into four segments. The performance of the newly calculated divergence increases quickly. However, in some cases, the parking lot image may contain reflections and shadows that may become an obstacle for our program. This situation requires further improvement on our algorithm.

ACKNOWLEDGEMENTS

Thanks to Dr. Bao Yufang for her help while I worked on this research project with her. She has not only taught me facts, but also trained me how to think. I appreciate her encouragement and support.

APPENDICES

Table 4.2-1 The divergence of Shannon entropy

#parking space	1	2	3	4	5	6	7
divergence	0.372935	0.216664	0.273873	0.537049	0.236931	0.340313	0.621766
#parking space	8	9	10	11	12	13	14
divergence	0.288281	0.243968	0.286818	0.295122	0.511336	0.531101	0.372994
#parking space	15	16	17	18	19	20	21
divergence	0.302888	0.537003	0.234666	0.368598	0.159561	0.458854	0.334106
#parking space	22	23	24	25	26	27	28
divergence	0.370038	0.422344	0.654068	0.339847	0.117539	0.146318	0.136475
#parking space	29	30	31	32	33	34	35
divergence	0.784599	0.418615	0.3304	0.591	0.420446	0.363836	0.333336
#parking space	36	37	38	39	40	41	42
divergence	0.217795	0.010995	0.531843	0.740243	0.361456	0.372278	0.297083
#parking space	43	44	45	46			
divergence	0.448098	0.30882	0.272758	0.577565			

Table 4.2-2 The divergence of Rényi entropy

#parking space	1	2	3	4	5	6	7
divergence	0.347874	0.251503	0.316284	0.461949	0.343199	0.315139	0.535673
#parking space	8	9	10	11	12	13	14
divergence	0.28143	0.322291	0.294821	0.31769	0.399929	0.458053	0.318854
#parking space	15	16	17	18	19	20	21
divergence	0.323045	0.422517	0.271473	0.384753	0.229623	0.437467	0.355821
#parking space	22	23	24	25	26	27	28
divergence	0.340604	0.440965	0.535468	0.412095	0.19524	0.380389	0.200766
#parking space	29	30	31	32	33	34	35
divergence	0.82613	0.433114	0.301715	0.52801	0.40344	0.41121	0.348058
#parking space	36	37	38	39	40	41	42
divergence	0.268101	0.105653	0.52909	0.661214	0.326712	0.356598	0.285223
#parking space	43	44	45	46			
divergence	0.369767	0.35847	0.291444	0.462186			

Table 4.2-3 The divergence of Tsallis entropy

#parking space	1	2	3	4	5	6	7
divergence	9.034772	11.1553	10.41411	8.551096	10.03644	9.27179	11.22963
#parking space	8	9	10	11	12	13	14
divergence	10.01091	9.858536	10.89559	10.82829	11.47841	9.005687	9.35281
#parking space	15	16	17	18	19	20	21
divergence	10.50362	11.47643	9.315569	9.724637	5.253798	10.555	8.82775
#parking space	22	23	24	25	26	27	28
divergence	9.179457	10.93583	11.51547	9.302237	4.830277	8.877255	5.5014
#parking space	29	30	31	32	33	34	35
divergence	10.27239	10.71572	9.562595	9.083675	11.89165	10.5911	10.13505
#parking space	36	37	38	39	40	41	42
divergence	9.172558	5.17314	5.626743	10.7496	11.13924	8.820618	11.35417
#parking space	43	44	45	46			
divergence	9.422013	10.27837	10.2971	11.7473			

Table 5-1 The total divergence of Shannon entropy

#parking space	1	2	3	4	5	6	7
divergence	0.91576	1.192372	1.1221	0.924319	1.032858	0.951386	1.18617
#parking space	8	9	10	11	12	13	14
divergence	1.114778	1.051704	1.137428	1.134932	1.171083	0.979769	1.054513
#parking space	15	16	17	18	19	20	21
divergence	1.214837	1.164392	0.965785	0.99565	0.786953	1.250556	1.398564
#parking space	22	23	24	25	26	27	28
divergence	1.100942	1.559699	1.35483	1.396264	0.535566	1.46431	0.619809
#parking space	29	30	31	32	33	34	35
divergence	1.446997	1.491033	1.265705	1.153989	1.523887	1.372157	1.123679
#parking space	36	37	38	39	40	41	42
divergence	1.039541	0.551094	0.613029	1.288756	1.30258	1.029046	1.219894
#parking space	43	44	45	46			
divergence	1.065291	1.227243	1.222607	1.1806			

Table 5-2 The total divergence of Rényi entropy

#parking space	1	2	3	4	5	6	7
divergence	1.597474	2.250541	2.021553	1.68303	1.973021	1.670978	2.201416
#parking space	8	9	10	11	12	13	14
divergence	2.175734	1.983948	2.262069	2.014416	2.181525	1.757251	1.857065
#parking space	15	16	17	18	19	20	21
divergence	2.388789	2.117833	1.83034	1.845346	1.555763	2.262002	2.694375
#parking space	22	23	24	25	26	27	28
divergence	1.922755	2.832767	2.429393	2.76392	1.149685	3.034684	1.260015
#parking space	29	30	31	32	33	34	35
divergence	2.634347	2.912228	2.306296	2.00678	2.67773	2.770588	2.068426
#parking space	36	37	38	39	40	41	42
divergence	1.90799	1.149253	1.165909	2.374849	2.576603	1.912614	2.261533
#parking space	43	44	45	46			
divergence	1.857347	2.531784	2.403596	2.15765			

Table 5-3 The total divergence of Tsallis entropy

#parking space	1	2	3	4	5	6	7
divergence	22.96011	30.60359	26.48308	24.29472	24.08571	26.47389	28.86154
#parking space	8	9	10	11	12	13	14
divergence	29.1549	26.3073	27.44703	28.50106	30.62081	24.84788	27.28879
#parking space	15	16	17	18	19	20	21
divergence	26.77437	30.53064	24.51922	27.94016	14.14521	30.89089	25.63338
#parking space	22	23	24	25	26	27	28
divergence	26.95503	28.78732	29.84083	26.10849	14.26468	25.77576	15.07159
#parking space	29	30	31	32	33	34	35
divergence	25.25013	30.26439	28.49565	25.32877	31.1435	27.08649	27.47822
#parking space	36	37	38	39	40	41	42
divergence	26.27185	14.59278	15.90754	31.37005	31.61003	26.45974	30.24413
#parking space	43	44	45	46			
divergence	27.52218	29.41514	29.65454	29.70782			

REFERENCES

[1] N. True, "Vacant parking space detection in static images", University of California, San Diego, 2007.

[2] C. Hsu, T. Tanaka, N. Sugie, K. Ueda, "Locating Vehicles in a Parking Lot by Image Processing", IAPR Workshop on Machine Vision Applications, 2002

[3] D. B. L. Bong, K. C. Ting, N. Rajaee, "Car-Park Occupancy Information System", Third Real-Time Technology and Applications Symposium, RENTAS 2006.

[4] T. Fabian, "An Algorithm for Parking Lot Occupation Detection", Computer Information Systems and Industrial Management Applications, 2008.

[5] K. Yamada and M.Mizuno, "A Vehicle Parking Detection Method Using Image Segmentation", J. IEICE (D-II), Vol. J82-D-II, no. 12, pp. 2316-2324, Dec. 1999.

[6] H. Wu, T. Zwick, "Automotive SAR for Parking Lot Detection", German Microwave Conference, 2009.

[7] R. M. Gray, "Entropy and Information Theory", Springer Verlag, New York, pp. 3, 8, 36, 1990.

[8] A. Rényi, "On measures of dependence", Acta Math. Acad. Sc. Hungar. 10, pp. 441-451, 1959.

[9] A. Rényi, "On measures of entropy and information", Selected Papers of Alfred Rényi 2, pp. 525-580, 1976.

[10] Tsallis, C., "Possible generalization of Boltzmann-Gibbs statistics", Journal of Statistical Physics 52, pp. 479-487, 1988.

[11] C. E. Shannon, "A mathematical theory of communication", Bell Syst. Tech. J. 27, pt. I,pp. 379-423; pt. II, pp. 623-656, 1948.

[12] J-F Cardoso, "Blind signal separation: statistical principles", Proceedings of the IEEE, special issue on blind identification and estimation 90 (1998), pp. 2009-2026.B. Ma A. O. Hero and O. Michel, "Alpha-divergence for image indexing and retrieval", Preprint, 2000.

[13] Y. He, A. Ben Hamza, H. Krim, "A Generalized Divergence Measure for Robust Image Registration", Transactions on Signal Processing, Vol. 51, No. 5, May 2003.

[14] M. Khader and A. Ben Hamza, "An Entropy-Based Technique for Nonrigid Medical Image Alignment", Combinatorial Image Analysis, Lecture Notes in Computer Science, 2011, Volume 6636/2011, 444-455.

[15] J. Lin, "Divergence measures based on the Shannon entropy", IEEE Trans. On

Information Theory 37, pp. 145-151, 1991.

[16] T. Maszczyk, W. Duch, "Comparison of Shannon, Rényi and Tsallis Entropy used in Decision Tree", Artificial Intelligence and Soft Computing–ICAISC 2008, Lecture Notes in Computer Science, pp 643-651, 2008.

[17] A. B. Hamza, Y. He, H. Krim, "An Information Divergence Measure for ISAR Image Registration", Proceedings of the 11th IEEE Signal Processing Workshop on Statistical Signal Processing, pp 130-133 2001.

[18] Y. Bao, "Nonlinear Image Denoising Methodologies", PhD dissertation, North Carolina State University 2002.

Lindsay Roberts
University of North Carolina at Pembroke
Faculty Mentor
Brandon Sanderson
Title of work:
On
Date: 2012
Medium: Intaglio with Chine Colle and A La Poupee
Framed dimensions:11 x 15"

Artist's Statement:
On represents the close relationships in my life. These interactions have defined and influenced my personal development. The position of the light plugs and socket are essential; the plugs are directed toward each other and seem to interact. The light sockets are positioned near my heart, reinforcing the importance of these relationships in my life.

Social Sciences

Tests of Transitive Inference in Rats Using an Automated Olfactometer

Alyse Kaszubski

University of North Carolina Wilmington

Faculty Mentor: Kate Bruce

University of North Carolina Wilmington

ABSTRACT

Transitive inference (TI) is considered to be higher order concept learning that requires animals to be able to learn a hierarchy and infer untrained relations among members of the hierarchy. TI has been demonstrated in a variety of species, including rats in which TI emerges when odor stimuli are used (Davis, 1992; Dusek & Eichenbaum, 1997; Jordan, 2009). Rats in these studies were initially trained on four overlapping simple odor discriminations AB+, BC+, CD+, and DE+. Choice of D given the presentation of the untrained pair 'BD' is said to demonstrate transitive inference. These successful TI studies all involved manual presentation of scented sand or scented lids as stimuli. In the present study a systematic replication of Davis (1992) was conducted with seven rats, using an automated olfactometer apparatus. Rats showed strong discriminative performances on trained baseline pairs; however, TI was not consistently observed. Additional stimulus sets were trained to determine whether multiple exemplar training would enhance emergence of TI. With repeated testing, four of the rats did show overall responding consistent with TI. While TI was not observed as clearly as in the manual procedures, the efficiency and objectivity of computerized assessment make this procedure an attractive option. Thus, we are exploring procedural variations to determine training necessary for the consistent emergence of TI.

Transitive inference (TI) is a type of higher-order concept learning. It represents the deduction of a relation between two stimuli that have never before been presented together by referring to a previously learned pattern, or hierarchy, of stimulus reinforcement (Davis, 1992). The hierarchy, A<B<C<D<E, is established through the training of the following adjacent pairs: AB+, BC+, CD+, and DE+. The "+" indicates that a choice of that stimulus will result in reinforcement. In this hierarchy, choosing E is always reinforced and choosing A never is. B, C, and D are all conditionally reinforced – meaning that reinforcement for choosing B, C, or D is dependent upon the other stimulus that a subject is presented with. For example, when B is presented with A, choosing B is always reinforced (A-B+). However, when B is presented with C, choosing B will not be reinforced (B-C+).

Tests for transitive inference occur through the presentation of a pair of two non-adjacent stimuli that have never been paired together before. Such tests include AC, AD, AE, BD, BE, and CE pairings. Reinforcement history of these stimuli prevents A and E from being commonly used in the measurement of TI. This is because A, in previously trained pairs, has never been reinforced, while E always is. The most effective test for TI would include two non-adjacent stimuli that have both been conditionally reinforced. Thus, presentation of stimuli B and D in a test is commonly used to verify the emergence of TI. As B and D have never been presented together and have similar reinforcement

histories, a subject needs to "infer" which stimulus will result in reinforcement based on the previously learned hierarchy. The choice of D over B in a BD test indicates that the subject has learned the hierarchy and has thus inferred the untrained transitive relation between B and D (Gillan, 1981). Many researchers believe that abstraction such as TI is unique to humans and may be required for the development of language (Hayes, 1989; Vasconcelos, 2008).

Transitive Inference in Humans

An example of a test for TI in humans is as follows: Mike is taller than Sam. Sam is taller than Phil. What is the relation between Mike's height and Phil's height? Though we have not been directly presented with this information, we can infer, based on the relation between Sam and the other two, that Mike is taller than Phil. Coming to this conclusion is demonstrating transitive inference. In 1970, Piaget claimed that in humans, transitivity was restricted to those beyond the concrete operational stage of development. This meant that children below the age of 7 years old were thought incapable of demonstrating TI (Piaget, 1970). However, Bryant & Trabasso (1971) performed an experiment that challenged Piaget's claim. They presented 60 children between the ages of 4 and 7 with five wooden rods of both different color and different length. The results of their experiment indicated that the children were indeed capable of demonstrating TI along a physical dimension (length). It is now thought that the inability of young children to demonstrate TI may be due to deficits of memory, rather than the lack of logic needed for transitivity (Vasconcelos, 2008).

Transitive Inference in Non-Humans

In Bryant & Trabasso's experiment, stimuli were presented along a physical dimension – that is, the hierarchy of reinforcement was constructed using a physical property of the stimuli – in this case, length of a wooden rod. In an experiment by Lazareva, Smirnova, Bajozkaja, Zorina, Rayevsky, & Wasserman (2004), TI was tested in hooded crows using visual stimuli in the form of discs on colored cards, creating the hierarchy A>B>C>D>E, where A was always reinforced and E never was. One group was presented with cards, on which every disc was the same size, and the other group was presented with cards that contained discs of decreasing diameters, coinciding with the hierarchy (A had disc with largest diameter, E had disc with smallest diameter). For the constant feedback group – those who were presented with cards with the same size discs – the results of the BD test did not differ from chance. However, for the group with the differing diameter discs, crows showed a strong preference for B over D in the probe test. The results of the experiment showed that crows were capable of demonstrating transitivity, but only when they were able to order stimuli according to a physical dimension – disc diameter (Lazareva et al., 2004).

Transitive inference, demonstrated by a variety of non-human species on a non-physical, or abstract, level, as well. That is, stimuli were ordered according to the experimenter, and not along a physical dimension. In 1981, Gillan demonstrated TI in chimpanzees. Using five containers with different colored lids, Gillan created a A<B<C<D<E hierarchy followed by the presentation of a BD probe test (Gillan, 1981). Replicating Gillan's training procedure, Boysen, Berntson, Shreyer, & Quigley (1993) also demonstrated transitive inference in chimpanzees using wooden boxes with colored lids as visual stimuli. In the Boysen et al. (1993) experiment, all three subjects chose D over B at a statistically significant level in the BD probe tests. To compare across studies,

in Gillan's (1981) experiment, only one of three subjects showed transitivity, while in the Boysen et al. (1993) study, transitive inference was consistently demonstrated across all subjects.

Transitivity also has been demonstrated in macaque monkeys (Treichler & Van Tilburg, 1996). Treichler & Van Tilburg used abstract visual stimuli in the form of multi-dimensionally different objects of common use. These objects were presented in pairs of two to construct the A<B<C<D<E hierarchy and a subject needed to slide the correct object across a track to receive reinforcement. Half of the subjects learned the A-E hierarchy, after which, an additional list was trained (F-J). Eventually the lists were combined by training the adjacent pair E-F+ to create a new, larger list (A-J). The other half of subjects were trained on the F<G<H<I<J hierarchy first, which was followed up by training the A-E hierarchy and linking the two lists through training E-F. Testing for the new ten-item list included the presentation of every possible combination of stimuli. Test pairs were labeled "adjacent" (presented stimuli were located next to each other on the list, A-J), "within-list" (stimuli presented were exclusively from one of the separately learned lists – A-E or F-J), and "between-list" (presented stimuli originated from separate lists i.e., A & H). Although more errors were made on tests when presented with stimuli situated within close proximities on the large hierarchy, subjects were able to successfully complete these tests, demonstrating transitivity (Treichler & Van Tilburg, 1996).

Von Fersen, Wynne, Delius, and Staddon (1991) additionally demonstrated the capacity of TI in pigeons using visual stimuli. Arbitrarily-shaped white-on-black stimuli were projected onto translucent keys in a modified operant chamber that the pigeons could peck to receive reinforcement. The hierarchy A>B>C>D>E was trained and performance on the BD test pair indicated the demonstration of transitivity, as all subjects chose stimulus B (Von Fersen et al., 1991).

Transitive Inference in Rats

Using an olfactometer, a device that delivers scents through nose poke holes in a modified operant chamber, Lionello-DeNolf & Mihalick (2006) demonstrated that rats have a propensity for olfactory stimuli over visual stimuli. They were able to train rats on both simple discrimination and reversal tasks using five different stimulus locations (Lionello-DeNolf & Mihalick, 2006).

Using their enhanced capacity for olfaction, Davis (1992) tested for TI in rats through the presentation of scented stimuli. Wooden doors soaked overnight in scent-filled jars were used in a T-maze and the hierarchy, A<B<C<D<E, was trained. An example of what a rat could have been exposed to is anise < almond < banana < coconut < vanilla. Two of these stimuli were presented in the T-maze, where the subject could push open one of the wooden doors at the arms of the maze to receive reinforcement (Davis, 1992). In addition to training the typical adjacent pairs (AB+, BC+, CD+, and DE+), Davis also trained the non-adjacent pairs, AC+, CE+ and AE+ to reinforce the established hierarchy as well as to acquaint the subject with non-adjacent pairs before the BD+ test (see Table 1). Subjects ultimately chose D over B in this test, at a statistically significant level, and the results of his experiment showed supportive evidence of transitive inference (Davis, 1992).

In 2009, Jordan successfully replicated the Treichler and Van Tilburg (1996) procedure of list learning with rats using manually presented olfactory stimuli in the form of cups of sand with scented lids. A subject needed to push the correct lid to have access to a reinforcer (a sucrose

pellet) buried in the sand. The hierarchy was trained through the presentation of all adjacent stimulus pairs during each phase. As phases progressed, pairs went from being presented in blocks of 6 trials each to random presentation of each stimulus pair. Once this hierarchy was trained, subjects underwent a phase of training where BD+ was included with the randomized adjacent pairs. The first response to the BD+ test was recorded and in the final phase, additional training also included the presentation of novel stimulus pairs, AC+, AD+, AE+, BE+ and CE+. Upon completion of this phase, a second list of scents was trained and an additional hierarchy was formed, F<G<H<I<J. The pair EF+ was trained to "link" the two lists and create a new hierarchy from A-J. Similar to Treichler and Van Tilburg (1996), tests for list linking included 45 trials of every possible combination of stimuli and this study found evidence of TI (Jordan, 2009).

Table 1. Davis (1992) training procedure.

Phase	Training
I	A-B+
II	B-C+
III	C-D+
IV	D-E+
V	A-C+
VI	C-E+
VII	A-E+

"+" and "-" note the stimuli that are reinforced and non-reinforced, respectively.

In 2011, Pacewicz attempted to replicate Jordan (2009) using an olfactometer. The same training procedure used by Jordan (2009) was also applied by Pacewicz (2011) in this automated procedure; however, list linking was not applied in the olfactometer. Phases of training contained sessions where all adjacent stimulus pairs were presented, from blocks of 12 to the random presentation of each pair. Probe tests for TI were conducted through the presentation of BD+ and XY+. The XY pair was comprised of two novel scents and was used as a control for any learning that may have occurred of the novel pairs. Of the two subjects that proceeded to this phase of testing, both performed poorly on the BD/XY test. This could be due to a failure of subjects to reach criterion before moving on to the probe test phase. Another concern Pacewicz expressed was that the programming used may not have been ideal for use in the olfactometer. Despite being given more training with baseline pairs than subjects from the Jordan (2009) study, subjects tested in the automated procedure used by Pacewicz (2011) did not show transitive inference.

The purpose of the present study was to change the procedure used by Pacewicz (2011) and see if TI would emerge using the olfactometer. Benefits of using an automated olfactometer in a study of transitive inference are that it significantly decreases experimenter error and is very time efficient. The use of an automated procedure eliminates the possibility of experimenter cues that could give subtle hints to the subject as to the correct response on a given trial. Moreover, using an olfactometer, subjects can get through as many as 80 trials in a period of 45 minutes. In this study, we replicate the Davis (1992) TI training procedure in an olfactometer. We expect this training to be more effective than that used by Pacewicz (2011) because each baseline stimulus pair will be trained individually, rather than all at once. In addition, following Davis (1992) we will be training non-adjacent stimulus pairs – excluding the BD test pair – which we hope will reinforce the learned hierarchy.

Figure 1. Automated apparatus. The operant chamber is shown in A. The nose pokes on the left side of the chamber are shown in B. C shows the olfactometers (where scented oil was stored). D shows the solenoids.

METHOD

Subjects

Seven 150-180-day-old male Sprague-Dawley rats (Rattus norvegicus) were used in this study. The rats were kept at approximately 85% of their free-feeding body weight and had unrestricted access to water. Approximately thirty minutes after finishing their daily sessions, subjects were fed roughly 15g of LabDiet rodent diet. When not participating in a session, the rats were individually housed and exposed to a 12:12 hr reverse light/dark cycle.

Apparatus

For testing, rats were placed in a standard operant chamber contained within a sound attenuating cubicle that prevented the penetration of outside light and sound (see Figure 1A). The front and back walls of the chamber were clear Plexiglas and the sides contained metal filler plates with three nose pokes and accompanying stimulus lights along the left wall. Each poke was equipped with scent delivery holes and photo beam sensors that detected subjects' responses (see Figure 1B). The right side of the chamber housed the pellet dispenser and food hopper. Correct responses throughout the trials were reinforced with the presentation of a 45 mg TestDiet sucrose pellet. The cubicle in which the chamber was housed also contained a fan that dispersed lingering scents during sessions and a house light that signified the beginning and end of a trial, as well as a timeout after an incorrect response.

Hooked up to the nose pokes, three olfactometers – equipped with five scent jars each – delivered odors through solenoids to either the left, right, or center pokes – though only the right and left were used for this experiment (see Figure 1C, 1D). Each scent jar contained a solution of liquid odorants from the Great American Spice Company (see Table 2 for complete list of scents).

Air pumps were used to dispense scent extracts to the appropriate nose poke locations through plastic tubing by delivering air over the extracts. The solenoids, regulated through MedPC© program software on an adjacent Dell desktop computer, controlled which scents were exposed to the air pumps and

delivered to subjects at any given time. A vacuum pump was also constantly in use to prevent the spread of scents throughout the chamber.

Procedure

Magazine training. During this phase of training, a sucrose pellet was dispensed into the hopper in the operant chamber once a minute. The hopper light was turned on to cue the rats that there was a delivery of reinforcement and this light remained on for 45s. After an inter-trial interval of fifteen seconds, the process began again with the delivery of the next pellet. This procedure was repeated twenty-five times, thus, each training session was 25 min. Criterion to move on to the next phase of training was the consumption of all 25 sucrose pellets.

Nose poke shaping. During the next phase of training, the left and right nose pokes were activated and any nose poke response was reinforced with a sucrose pellet. A response was recognized when the subject's nose entered the nose poke and broke the photo beam inside. Each disturbance of a photo beam was noted as one response and reinforcement was delivered to the chamber's hopper. The hopper light remained on for five seconds and was followed by an inter-trial interval (ITI) of 30s. To move on to transitive inference training, subjects needed to meet a criterion of at least 25 responses in each nose poke in a single session.

Transitive inference (TI) training

In Phase One of TI training, rats were exposed to two scents, A and B, from scent set 1 (see Table 2). In each of eighty trials, a response choosing scent B, Honey, was always reinforced, while a response choosing scent A, Pecan, was never reinforced (A-B+). This A-B+ training used one of the eight Med Associates programs for Phase One, randomly selected each day. Eight programs were created per phase of training – to ensure that the rats weren't learning a pattern of reinforcement by being subjected to the same configuration each session – and consisted of eighty random, counterbalanced L-R trials so that a particular scent was not dispensed from the same nose poke more than three times in a row. Responses were recognized by the breaking of the photo beam inside the correct nose poke. For the first day, a single response in the appropriate nose poke resulted in the delivery of a sucrose pellet as reinforcement (Fixed Ratio 1, or FR1). The hopper light remained on for 5s and was followed by a 25s inter-trial interval. Incorrect responses were recorded as made, but the trial did not advance unless a correct response was made or 60s of incorrect or no responding occurred. Each trial was followed by a 25s ITI.

The criterion to advance was increased the following day to FR2, which required two responses in the appropriate nose pokes

Scent set 1	Scent set 2	Scent set 3	Scent set 4
A – Pecan	F – Butter	K - Maple	P – Brandy
B – Honey	G – Peanut Butter	L – Tangerine	Q – Vanilla Butternut
C – Chocolate	H – Strawberry	M – Butterscotch	R – Almond
D – Grape	I – Lemon	N – Blackberry	S – Licorice
E – Watermelon	J – Blueberry	O – Cherry	T - Cinnamon

Table 2. Sets of scents used in TI training. Scent set 1 used for A-E training; scent set 2 used for F-J training; scent set 3 used for K-O training; scent set 4 used for P-T training

before reinforcement. Each day, the fixed ratio of responding was increased by one and this pattern continued until a FR5 schedule was established. If a subject's responses significantly slowed or stopped altogether, the ratio decreased until a subject was once again responding at a consistent level before increasing again. The FR5 schedule was then used for each subsequent phase of training. At the end of each session, correct and incorrect trials (five responses in the wrong nose poke) were displayed and recorded. Criterion to move to Phase Two of TI training was two consecutive sessions at 83% correct or higher on an FR5 schedule of reinforcement.

In Phase Two, subjects were exposed to scent B, Honey, and scent C, Chocolate. Responses choosing Chocolate (C) were reinforced. Honey (B) was never reinforced, but rather exposed to an extinction contingency. One of eight B-C+ Med Associates programs was assigned each day of training. Correct responses were reinforced by the release of a sugar pellet into the hopper on an FR5 schedule. Incorrect nose pokes were recorded and five or more responses in the nose poke and subjects had to meet a criterion of at least 83% correct for two consecutive sessions to advance to Phase Three.

Phase Three consisted of the exposure to scent C, Chocolate, and scent D, Grape, and Phase Four included the exposure to scent D, Grape, and scent E, Watermelon. These phases were procedurally identical to Phase Two, implementing the same criterion to advance to the next phase of training.

At the end of Phase Four, a subject had been exposed to scents A through E and a hierarchy of scents has been reinforced as follows: A<B<C<D<E. Phases Five, Six, and Seven were adapted from the Davis (1992) procedure and involved the training of non-adjacent stimulus pairs. In Phase Five, scents A and C were presented to the subject with the contingency A-C+, reinforcing the choice of scent C over scent A and strengthening the scent hierarchy. A criterion of 83% correct or higher for two consecutive sessions advanced a subject to Phase Six. Phases Six and Seven were procedurally identical to Phase Five and involved the presentation of the C-E+ and A-E+ contingencies, respectively, using the same criterion to advance to the next phase of training. The training of all non-adjacent stimulus pairs served to further strengthen the emerging scent hierarchy – reaffirming that E was always reinforced, where A never was – before Phase Eight, BD probe testing.

Phase Eight consisted of the presentation of scents B and D, a previously never-before-seen combination of scents. The first day of Phase Eight administered the BD Probe Test. It was run similarly to sessions from other phases, except the first six trials were unreinforced. These trials were recorded separately, as the BD test was the measure of transitive inference used for this experiment. Trials 7-80 were reinforced B-D+. After the first probe session, Phase Eight continued as all other phases, running one of eight B-D+ programs each day until the subject obtained a criterion of 83% correct or higher for two consecutive sessions.

When criterion on BD was met, subjects repeated Phases One– Eight three additional times with scent sets 2, 3, and 4, respectively (see Table 2). These multiple exemplars provided additional training and allowed for generalization of transitivity across scents. Figure 2 shows a summary of the TI training procedure.

Data Analysis

The results of the probe tests were used to determine whether a subject demonstrated transitive inference. In order to express this abstraction, subjects needed to choose the

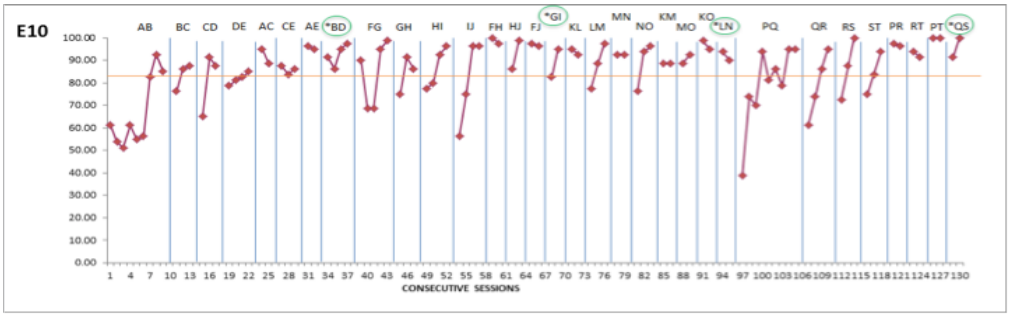


Figure 3. Subject data for E10. Phases separated by vertical blue lines. Probe Sessions circled, Criterion indicated by horizontal ilne at 83%.

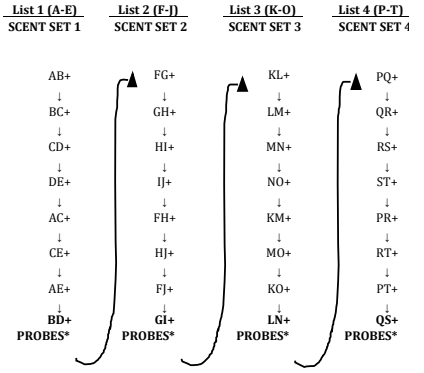


Figure 2. Summary of TI training procedure. Criterion to move to next phase is two consecutive sessions at least 83% correct. Criterion to move to next List (and scent set) when two consecutive sessions at least 83% correct met on probe conditions (BD, GI, LN).

scent in the "D" position over the one in the "B" position in the hierarchy (also I over G, N over L, S over Q) on 10 out of 12 unreinforced probe trials (two consecutive probe sessions of six trials each). 10/12 is statistically significant (binomial test, $p<.05$). If this level of significance is reached, because the analyzed trials were non-reinforced, transitivity can be said to have emerged, rather than a subject learning to choose D over B because it has been previously reinforced for that choice. Because multiple exemplars were trained in hopes of facilitating the emergence of transitivity, the main tests taken into consideration to determine TI were the LN+ and QS+ probe tests. However, we also examined overall performance across all exemplar sets, again using binomial probabilities.

RESULTS

Figure 3 shows the data for one of the subjects, E10, as an example of how each subject progressed through the study. His data are described in detail below and then the data for the rest of the subjects are presented in summary form in Tables 3.1-3.4 and Table 4.

As seen in Figure 3, subject E10 reached criterion for Phase One (A-B+) in 9 sessions, for Phases Two (BC) and Three (CD) in 3 sessions, for Phase Four (DE) in 4 sessions, and for Phase Five (AC) after 2 sessions. For Phase Six (CE), though E10 appeared to meet criterion after 2 sessions, the first session of the phase has to be discounted because the wrong scents were loaded in the olfactometer for that session. E10 did, however, reach criterion for this phase in 2 additional sessions. Criterion was also reached in 2 sessions for Phase Seven (AE). Criterion for Phase Eight (BD) appeared to have been reached after 2 sessions – however, due to an error in calculation, the session was incorrectly scored, and actual criterion was met after an additional 2 sessions. On the BD probe test, E10 scored 3/6 correct.

Though E10 scored above 83% on the first day of FG training, it took 5 sessions for E10 to meet criterion for this phase. Criterion for Phase GH was met in 3 sessions, for Phases HI and IJ, 4 sessions,

and for Phases FH, HJ, FJ, and GI, 2 sessions each. The result of the GI probe test for E10 was 4/6 correct.

Phase KL lasted for 2 sessions, as E10 met criterion. Criterion was met in 3 sessions for Phase LM, 2 sessions for Phase MN, 3 sessions for Phase NO, and 2 sessions each for Phases KM, MO, KO, and LN. The result of the LN probe test for E10 was 5/6 correct.

E10 took 9 sessions to reach criterion for Phase PQ, oscillating between responding at above 83% correct and below. 4 sessions were needed for E10 to reach criterion for Phase QR, 3 sessions each for Phases RS and ST and 2 sessions each for Phases PR, RT, PT, and QS. E10 scored 5/6 correct on the QS probe test.

On the last two probe tests (LN & QS), E10 responded with a combined score of 10/12. This number is statistically significant, demonstrating that E10's behavior was consistent with transitivity (binomial test, $p<.05$). Further, examining E10's overall performance on TI probes, this rat showed choice consistent with TI on 17/24 possible probe tests. This is significantly higher than expected by chance (binomial test, $p<.02$).

Tables 3.1-3.4 show the number of sessions each phase lasted for the 7 subjects used in this experiment. Phases for all subjects lasted an average of 3.6 sessions with a good bit of variation (up to 22 sessions for a single phase). Asterisks denote any unusual procedural variations.

AB	BC	CD	DE	AC	CE	AE	BD
9	3	3	4	2	4*	2	4**
8***	3	7	5	3	3	2	3
10	4	9	4	2	2	3	2
8***	4	6	7	7**	2	2	2
8***	4*	6	5	2	2	2	3
8	3	5	7	2	2	2	2
8***	3	9	7	5	2	2	5

Table 3.1. Summary of phase duration for all subjects for A-E hierarchy (scent set 1). Numbers in table indicate sessions to criterion.

	FG	GH	HI	IJ	FH	HJ	FJ	GI
E10	5	3	4	4	2	2	2	2
E25	2	3	5	6	2	3	2	3
E26	2	4	3	4	2	2	2	2
E27	6	9	6	10	22	5	2	3
E28	6	6**	4	10	3	3	2	3
E29	4	4	3	3	2	3	2	2
E30	4	3	2	4	2	2	2	2

Table 3.2. Summary of phase duration for all subjects for F-J hierarchy (scent set 2). Numbers in table indicate sessions to criterion.

	KL	LM	MN	NO	KM	MO	KO	LN
E10	2	3	2	3	2	2	2	2
E25	4	6	4	8	3	2	4	3
E26	2	3	5	5	4	2	2	5
E27	2	5	3	3	5	2	2	3
E28	2	3	4	8	3	3	2	3
E29	2	3	3	3	2	2	2	3
E30	3	4	4	6**	4	--	2	2

Table 3.3. Summary of phase duration for all subjects for K-O hierarchy (scent set 3). Numbers in table indicate sessions to criterion.

	PQ	QR	RS	ST	PR	RT	PT	QS
E10	9	4	3	3	2	2	2	2
E25	3	3	5	4	2	2	2	3
E26	3	3	4	3	2	2	4	2
E27	4	9**	5**	8	4	2	2	3**
E28	3	6	6	4	2	3	2	3
E29	3	4	4	6	3**	2	2	2
E30	4	4	3	3	4	6	2	3

Table 3.4. Summary of phase duration for all subjects for P-T hierarchy (scent set 4). Numbers in table indicate sessions to criterion.

**indicates long phase durations due to incorrect olfactometer set-up.*
***indicates longer phase duration due to calculation error.*
****indicates subject reached criterion before FR5 schedule so 2 additional sessions were done.*

Rat	BD Test	GI test	LN test	QS test	Total
E10	3/6	4/6	5/6	5/6	17/24*
E25	4/6	3/6	3/6	4/6	14/24
E26	6/6	3/6	4/6	3/6	16/24*
E27	5/6	3/6	3/6	5/6	16/24*
E28	4/6	3/6	1/6	4/6	12/24
E29	3/6	5/6	3/6	4/6	15/24
E30	3/6	4/6	6/6	3/6	16/24*
Totals	28/42*	25/42	25/42	28/42*	
Mean	66.7%	59.5%	59.5%	66.7%	

Table 4. Summary of probe test results. Shaded boxes indicatre a potential for the emergence of TI. Pairs of boxes bolded indicate a demonstration of transitive inference.

**indicates statistical significance (binomial test, $p<.05$)*

Table 4 shows a summary of all subjects' performance on the BD, GI, LN, and QS probe tests. Probe performance across scent sets for each rat is shown on each row (24 possible probes). On these combined probe tests, E10, E26, E27, and E30 all showed above chance performance. Further, shaded boxes depict sets where behavior has the potential for a significant emergence of TI (if performance remains consistent). Pairs of boxes bolded indicate a consistent demonstration of transitive inference with adjacent scent sets. Only one rat (E10) met criterion for at least 10/12 TI probes on adjacent scent sets; however, there are several examples of 5/6 and 6/6 probe performance. Four rats show some indication of TI.

In addition, the final row shows the total score out of 42 probe trials as well as the mean percent correct for each test (each of the 7 rats was tested with 6 probe trials at each scent set). Considering the performance of all rats at each scent set probe, there was evidence for TI with the BD [first probe] test and QS [last probe] test; in each case, 28/42 probe tests showed behavior consistent with TI (binomial test, p=.012). Probe performance with the GI and LN tests was less compelling (25/42, binomial test, p<.06).

DISCUSSION

While there was some evidence of TI using this procedure, it was not consistent. E10 was the only subject to demonstrate TI on the last two probe tests (LN & QS) at a level that was statistically significant, though other subjects showed a potential for TI to emerge. Both E26 and E27 chose D over B in the BD probe test 6/6 and 5/6 times, respectively. If this pattern were to remain consistent, we might have seen TI emerge on the final probe tests as well, but this was not the case. For E27, this pattern was repeated on the QS probe test, however, because E27 only chose N over L on 3/6 of the test trials, we cannot say that E27 displayed TI at a statistically significant level. In addition, E29 chose I over G on 5/6 test trials – a pattern that, if repeated, would have likely resulted in the demonstration of transitivity by E29 on the final two probe tests. E30 did display some transitivity by choosing I over G on 4/6 trials and N over L on all test trials (6/6), but did not show TI on the last probe test.

For the individual probe tests, subjects showed a collective emergence of TI clearly on both the BD and QS tests and fairly well on the GI and LN probe tests. Four of the 7 subjects (E10, E26, E27, and E30) demonstrated transitivity at a statistically significant level when results for all probe tests were lumped together. However, the results seen in this experiment are not as conclusive as the emergence of TI seen in the Davis (1992) experiment where all subjects showed TI consistently.

Something that may have prevented the consistent emergence of transitive inference in this experiment was the procedure used to train subjects on adjacent and non-adjacent pairs. The inclusion of non-adjacent pairs in training, while useful as other tests of transitive inference, may have blocked the overall emergence of this abstraction. Because of the time it took to train A-C+, C-E+, and A-E+, it had been anywhere from 6 to 11 sessions since a subject had been exposed to scent D and up to 25 sessions since exposure to scent B. This holds true for the multiple exemplar training as well, with 9-45 sessions since exposure to the critical scent.

As a potential solution to this problem, we are currently testing for transitive inference in the olfactometer using the Gillan (1981) procedure. Where Davis (1992) trained all adjacent pairs (AB+, BC+, CD+, DE+) in addition to non-adjacent pairs (AC+, CE+, AE+), Gillan's training emphasizes the rehearsal of all previously trained adjacent

pairs (see Table 5). After A-B+ training, subjects are trained with B-C+, followed by a phase that combines both AB+ and BC+. After criterion is met for both pairs within a session for two consecutive sessions, subjects are trained with C-D+. The next phase of training combines all three of these phases (AB+, BC+, and CD+) in a single session. Once criterion is met for all pairs in this phase for two consecutive sessions, subjects are then trained with D-E+. A final phase combines all of the previously learned pairs before BD testing (Gillan, 1981). We hope that the lack of non-adjacent pair training as well as the rehearsal of all previously learned pairs seen in the Gillan (1981) procedure will facilitate transitive inference in the olfactometer.

Table 5. Gillan (1989) training procedure. Emphasis is placed on rehearsal of previously learned adjacent pairs. "+" and "-" note the stimuli that are reinforced and non-reinforced, respectively.

Phase	Training
I	A-B+
II	B-C+
III	A-B+, B-C+
IV	C-D+
V	A-B+, B-C+, C-D+
VI	D-E+
VII	A-B+, B-C+, C-D+, D-E+

Of course, the main difference between the present study and Davis (1992) is that, while Davis used a manual procedure to test for transitive inference, we used an olfactometer. While the use of the olfactometer proved to be more time efficient and eliminated any experimenter cues, it may have also created some unforeseen problems. First, one difference from the Davis (1992) procedure is the delay between response and reinforcement. In the Davis (1992) experiment, when subjects pushed the correct scented door open with their noses, they were immediately exposed to the food reinforcer that lay behind the door. In the present study, reinforcement for five correct nose pokes (FR5) resulted in a sugar pellet being dispensed from a food hopper located behind the subject, on the opposite side of the operant chamber. The rat had to turn around in the chamber and walk to the food hopper. This delay may have resulted in a lack of direct connection between the response to the scented stimulus and reinforce delivery. Additionally, the extra trials per session that the olfactometer allowed may have actually hindered learning in the subjects. A study by Erickson (1941) showed that massed practice, such as that seen in the olfactometer, can result in more variable behavior in subjects, and thus, the occurrence of additional errors.

Another difference between the current study and Davis (1992) is that this experiment exposed subjects to multiple exemplars to provide additional training, where Davis took another approach. Following each of the BD tests, Davis re-trained a session of A-E+ before exposing his subjects to another BD session. Davis' subjects could be exposed to as many as 20 total BD trials for a single scent set, where the current experiment only used 6 BD probe trials per scent set. The additional exemplars were trained in hopes of achieving similar significance to the results seen by Davis (1992). However, it appears from the results of the current experiment that only partial concept learning may have emerged. The performances on BD, GI, LN, and QS probe tests seemed to be between chance and baseline – partial concept learning – where full concept learning would be characterized by performance similar to baseline on probe trials (Wright & Katz, 2007). Thus, the results of the current experiment are not conclusive enough to claim to full emergence of TI in rats in an olfactometer.

A methodological change to consider for future studies is to increase the balancing of stimuli across training. In the current study

all rats received training on scent sets in the same order (regarding the administered order of both individual scents and scent sets). A balancing procedure would remove the potential alternative explanation that certain scents or sets of scents were easier or more difficult to discriminate than others.

Another methodological issue that may have hindered the emergence of transitive inference in the olfactometer relates to ecological significance. A study by Delius (1992) demonstrated the importance of an ecologically significant procedure using pigeons. That is, his results showed the importance of having stimuli similar to those found in a subject's natural environment. The Delius (1992) procedure involved the discrimination between spherical and non-spherical objects, which was rapidly acquired. After acquisition, novel spherical and non-spherical stimuli were tested as well as pictures of three-dimensional stimuli. Pigeons learned to discriminate between three-dimensional objects more quickly than two-dimensional ones. According to Delius, such quick learning had to have occurred because three-dimensional stimuli are more closely related to those in a pigeon's natural environment.

In a study by Wright and Delius (1994), pigeons were trained with match-to-sample (identity training) or oddity-from-sample (non-match-to-sample) tasks by digging in gravel – an operant response adapted from natural pigeon foraging behavior. Pigeons were able to learn this task at a faster rate than tasks learned through traditional key-peck training methods. This is consistent with the model of learning three-dimensional stimuli discriminations faster than two-dimensional stimuli. The presence of three-dimensional over two-dimensional stimuli in an experiment, as seen in a pigeon's natural environment, may increase the ecological significance of the experiment (Wright & Delius, 1994). Additionally, pecking at gravel on the floor has a higher ecological significance than pecking stimuli presented vertically on a wall because floor pecking is more similar to pigeons' natural foraging behavior (Wright, 1997). Unlike the three-dimensional characteristic of the stimuli used by Wright and Delius (1994), scents in the olfactometer have more of a two-dimensional quality. They are not seen in a rat's natural environment in the same manner that they are presented by the olfactometer. The olfactory stimuli manually presented in the form of scented lids used by Jordan (2009) are closer to such three-dimensional stimuli and thus, may have contributed to the demonstration of TI in that study. The ecological validity of rats pushing scented lids and digging in sand for reinforcement is greater than that of the nose poke behavior trained in this study and that of Pacewicz (2011). Perhaps this is one reason that transitive inference was seen consistently in rats by Jordan (2009) and not by Pacewicz (2011) or in the present study. However, though training in the olfactometer is less ecologically significant than a manual procedure, with extensive training, this phenomenon may not hinder the emergence of TI. We hope with the rehearsal training of the Gillan (1981) training procedure will facilitate transitive inference and that TI will indeed be demonstrated using the olfactometer.

While higher order learning was once thought to be an exclusively human ability, the expanding amount of evidence showing transitive inference in non-humans suggests that this might not be the case. The capacity for transitive inference has been shown in a variety of animals, including primates (Boysen et al., 1993; Gillan, 1981; Treichler & Van Tilburg, 1996), birds (Lazareva et al., 2004; Von Fersen et al., 1991), and rats (Davis, 1992; Jordan, 2009) – all of which are social species. Perhaps

the capacity for transitivity to emerge is related to shared characteristics of these social groups. For example, transitive inference is essential for the emergence of dominance hierarchies in social groups and may factor into the determination of which individual to challenge based on the physical characteristic of size. Just observing a fight can result in important information being relayed to bystanders. If an unknown enemy defeats an individual that has already beaten you, you can use TI to infer that this enemy is formidable to you as well.

In addition, transitivity is an important aspect of stimulus equivalence, which involves the grouping of arbitrary stimuli into one class (Sidman & Tailby, 1982). It is essential to the formation of language, as a given stimulus equivalence group may include several different items in one category, for example, the visual word, auditory sound, and image of "dog." What initially begins as a meaningless symbol, through stimulus equivalence, develops meaning and eventually combines with other symbols to create language (Schusterman, Reichmuth Kastak & Kastak, 2003). Further studies could identify whether abstract learning, such as transitive inference and stimulus equivalence, is limited to species most evolutionarily similar to humans or if it can be generalized across non-human species.

REFERENCES

Calhoun, J. B. (1963). *The Ecology and Sociobiology of the Norway Rat.* Bethesda, Maryland: US Department of Health, Education, & Welfare.

Davis, H. (1992). Transitive inference in rats (*Rattus norvegicus*). *Journal of Comparative Psychology, 106(4),* 342-349.

Delius, J. D. (1992). Categorical discrimination of objects and pictures by pigeons. *Animal Learning and Behavior, 20(3),* 301-311.

Dusek, J. A., & Eichenbaum, H. (1997). The hippocampus and memory for orderly stimulus relations. *Proc. Natl. Acad. Sci., 94,* 7109-7114.

Gillan, D. J. (1981). Reasoning in the chimpanzee: II. Transitive inference. *Journal of Experimental Psychology, 7(2),* 150-164.

Hayes, S. C. (1989). Nonhumans have not yet shown stimulus equivalence. *Journal of the Experimental Analysis of Behavior, 51(3),* 385-392.

Jordan, L. (2009). List linking as a tool to test transitive inference in rats. *Explorations: The Journal of Undergraduate Research and Creative Activities for the State of North Carolina, 4,* 85-107.

Kinahan, A. A., & Pillay, N. (2008). Dominance status influences female reproductive strategy in a territorial African rodent *Rhabdomys pumilio*. *Behavioral Ecology and Sociobiology, 62,* 579-587.

Lazareva, O. F., Smirnova, A. A., Bagozkaja, M. S., Zorina, Z. A., Rayevsky, V. V., & Wasserman, E. A. (2004). Transitive responding in hooded crows requires linearly ordered stimuli. *Journal of the Experimental Analysis of Behavior, 82,* 1-19.

Lazareva, O. F., & Wasserman, E. A. (2006). Effects of stimulus orderability and reinforcement history on transitive responding in pigeons. *Behavioural Processes, 72,* 161-172.

Lazareva, O. F., & Wasserman, E. A. (2008). Categories and concepts in animals. *Learning and Memory: A Comprehensive Reference, 1,* 197-226.

LeBouef, B. J. (1974). Male-male competition and reproductive success in elephant seals. *Amer. Zool., 14(1),* 163-176.

Lionello-DeNolf, K. M., & Mihalick, S. M. (2006). An automated olfactory discrimination procedure with rats. *The Behavior Analyst Today, 7(4),* 560-571.

McIntire, K. D., Cleary, J., & Thompson, T. (1987). Conditional relations by monkeys: Reflexivity, symmetry, and transitivity. *Journal of the Experimental Analysis of Behavior, 47(3),* 279-285.

Modig, A. O. (1996). Effects of body size and harem size on male reproductive behavior in the southern elephant seal. *Animal Behaviour, 51(6),* 1295-1306.

Otto, T., & Eichenbaum, H. (1992). Complementary roles of the orbital prefrontal cortex and the perirhinal-entorhinal cortices in an odor-guided delayed-nonmatching-to-sample task. *Behavioral Neuroscience, 106(5),* 762-775.

Schusterman, R. J., & Kastak, D. (1993). A California sea lion (*Zalophus californianus)* is capable of forming equivalence relations. *The Psychological Record, 43,* 823-839.

Sidman, M. (2000). Equivalence relations and the reinforcement contingency. *Journal of the Experimental Analysis of Behavior, 74(1),* 127-146.

Sidman, M., Rauzin, R., Lazar, R., Cunningham, S., Tailby, W., & Carrigan, P. (1982). A search for symmetry in the conditional discriminations of rhesus monkeys, baboons, and children. *Journal of the Experimental Analysis of Behavior, 37(1),* 23-44.

Slater, P. J. B., Rosenblatt, J. S., Snowdon, C. T., Roper, T. J. (2002). *Advances in the study of behavior.* San Diego, CA: Academic Press.

Spritzer, M. D., Meikle, D. B., & Solomon, N. G. (2004). *Journal of Comparative Psychology, 118(3),* 332-339.

Treichler, F. R., & Van Tilburg, D. (1996). Concurrent conditional discrimination tests of transitive inference by macaque monkeys: list linking. *Journal of Experimental Psychology*, *22(1)*, 105-117.

Von Fersen, L., Wynne, C. D. L., Delius, J. D., & Staddon, J. E. R. (1991). Transitive inference formation in pigeons. *Journal of Experimental Psychology, 17(3),* 334-341.

Weaver, J. E., Steirn, J. N., Zentall, T. R. (1997). Transitive inference in pigeons: control for differential value transfer. *Pyschonomic Bulletin & Review, 4(1),* 113-117.

Wright, A. A., & Delius, J. D. (1994). Scratch and Match: pigeons learn matching and oddity with gravel stimuli. *Journal of Experimental Psychology, 20(1),* 108-112.

Native American Mascot Controversy and Mass Media Involvement: How the Media Play a Role in Promoting Racism through Native American Athletic Imagery

Elizabeth A. Locklear
University of North Carolina at Pembroke
Faculty Mentor: Judy Curtis
University of North Carolina at Pembroke

ABSTRACT
Over the past 30 years, there has been a national debate as to whether school and professional sports teams should use Native American imagery as their mascots, nicknames, and/or logos. During the 1990s, scholars and media critics began to examine the use of Native American imagery in media. Research has shown that some people support the use of Native American athletic imagery depicted in media, while others oppose these. This research paper examines the use of Native American athletic imagery in media and viewpoints on media responsibility. By applying the framing and stereotype theories found in the literature, the author concludes that the media promote racism through the use of Native American athletic imagery.

For approximately 30 years, there has been a nationwide dispute as to whether school and professional sports teams should use Native American imagery as their mascots, nicknames, and/or logos. At a minimum, there are two conflicting viewpoints: (1) Keeping this imagery honors Native American people, supports nostalgic feelings, and saves funding; and (2) Keeping this imagery is offensive and degrading because it is sacred to Native Americans and perpetuates negative stereotypes. Supporters argue these images are complimentary, not "hurtful," and are not offensive to all Native Americans. People in opposition cite research that shows lasting negative self-esteem effects on Native and non-Native individuals from misconceived, cartoonish, and dehumanizing imagery. Throughout the 1990s, scholars and media critics began to examine the use of Native American imagery in media. This examination presented two conflicting viewpoints. Research has shown that some people support the use of Native American athletic imagery depicted in media, while others oppose the use. Supporters argue that the media should remain objective and report relevant news without showing their personal opinions. Opponents argue that the media can never be entirely objective and should consider the ethical and political concerns that surround this issue.

While some media outlets have spoken out against Native American athletic imagery, many have not. The *Oregonian* and the

Minneapolis Star Tribune have implemented policies that discontinued each newspaper's use of nicknames and imagery that might be offensive to some readers. Other news organizations who have not taken these steps reason that the media's responsibility is to only report news and not strive to generate societal change. This research paper seeks to explore and answer the following question: Do the media promote racism through Native American athletic imagery or support those who are offended? It will also consider media responsibility on controversial issues including news selections on the imagery controversy.

Review of the Literature: Native American Athletic Mascots, Nicknames, and Logos and Media Involvement

According to the National Collegiate Athletic Association, for approximately 30 years there has been a debate across the country as to whether public schools, colleges, universities, and professional sports teams should be allowed to use imagery of Native Americans as their athletic mascots, nicknames, and/or logos (Native American Mascots, 2008). The debate has focused on whether athletic teams using this imagery should be forced to change to some other image that does not reflect any racial group thereby, totally eliminating the depiction of Native Americans in this way. One component of the debate focuses on the involvement of mass media. Native American athletic imagery and mass media involvement provokes a discussion of whether the media promote racism by using the imagery or promote support through covering the controversy. It also introduces the discussion of whether the media should use Native American athletic imagery in news reports.

Over time, researchers have conducted studies and observations on Native American imagery depicted in mass media. Both the framing and stereotype theories have been applied in some of these studies and observations. According to Baran and Davis (2012), the framing theory "assumes that people use their expectations of situations to make sense of them and determine their actions in them" (p. 354). Theorists state that the media contribute to these expectations. The stereotype theory is the "view that the mass media reinforce the dominant segment of society's existing patterns of attitudes and behavior toward minorities by perpetuating rigid and usually negative portrayals" (DeFlur & Dennis, 1994, p. 639).

Scholars have also found that most of the images in mass media are offensive and degrading to Native people and is not an honor, but is instead, a mockery of Native American culture, traditions, history, religion and self-worth because they portray Native Americans through stereotypes. These stereotypes "ridicule" Native Americans, create "lowered public expectations" and cause "reduced ability to interact with non-Native Americans" (Himebaugh, 1994 p. 3). According to Merskin (1998), the media symbolically annihilate Native Americans by "ignoring, excluding, marginalizing or trivializing a particular group" (p. 335). Merskin (1998) further states that "seeing oneself portrayed in the media can serve in constructing a view of oneself and of the world outside" (p. 335).

Although the issue of Native American athletic imagery has been discussed for many years, the involvement of media did not become widely discussed in "popular media" until the 1990s (Jensen, 1994). Scholars found that as opponents spoke out against the use, activism surrounding the issue continued to grow. With growing activism, the issue initiated changes within the media as well as on college campuses. Activism on the mascot issue grew even more with the founding of the National Coalition on Racism in Sports and the Media in Minnesota in 1991 (Hofmann,

2005). The coalition planned protests at various high-profile sporting events, such as the Super Bowl and World Series, which attracted the attention of the local and national media. Hofmann (2005) writes, "Scholarly journal articles and commentaries in newspapers forced schools and universities to examine their level of commitment to issues of diversity and to creating more welcoming environments for students, staff, and teachers" (p. 2).

Opposing Viewpoints

Researchers have found at least two distinct conflicting points of view on this debate. One point of view supports the use of Native American athletic imagery often depicted in the media. People who take the opposite point of view argue against the use of Native American sports imagery in media. When reviewing these perspectives, Jensen (1994) argues the media should consider their ethical and political responsibility, and if the media should make independent decisions to stop using Native American athletic imagery. The following information will analyze and respond to these points of view. Consideration will also be given as to whether the media promote or oppose racism toward Native Americans.

Supporting Views of Native American Athletic Imagery Depicted in Media

Individuals who support or defend Native American athletic imagery in media argue that the media should not take a stance and solely report on the issue. In 1992, Jensen (1994) conducted a study on journalists' views on the issue and found some journalists argued that "people are becoming too sensitive to the possible offensiveness in language and there was no reason for changing the names" (p. 19). These journalists labeled the movement to end the use of Native American images as a misguided attempt to be "politically correct". Beadle (2002) writes, "Where will it end? Will the Fighting Irish of Notre Dame have to change its name because it's offensive to Irish people?" (p. 1). Jensen (1994) also found that the minority of journalists in the study reasoned "because the larger society should not take action, no action by the newspaper was necessary" (p. 19). However, the majority agreed that "the use of Native American names and images for teams was problematic, but concern that the newspaper erred in taking independent action" (p. 19).

Jensen (1994) found the most common response of journalists who supported or defended Native American athletic imagery in media was not that they accepted the imagery, but that media should remain objective and stay out of the controversy. Commonly, journalists argue that the media should "strive to be impartial or objective as possible. Reporters are neutral observers, not advocates or participants; they provide facts and details of stories, not their own opinions" (Bender, Davenport, Drager, & Fedler, 2009, p. 72). In 1992, the president of NBC stated, "Newspapers are supposed to be mirrors and tribunes and records of society, journals and registers of fact - that's how they got their names. Their news pages are not supposed to be edited to bring about social change" (Jensen, 1994, p. 20).

The following statement by Jensen (1994) presents the opinions of many commentators who support or feel no action should be taken to eliminate Native American athletic imagery in media. "Journalists do their job best when they hold up a mirror to the world and let readers see the truth. Sometimes that involves stating truths that are unpleasant or airing opinions with which many disagree. The job of professional editors is to take the heat, both from pressure groups in society and the government,

and print those truths in the face of complaints" (p. 20). Thus, supporting arguments reason it is a journalist's obligation to not get involved, but to inform the public while remaining impartial.

Opposing Views of Native American Athletic Imagery Depicted in Media

Individuals who argue against the use of Native American athletic imagery in media reason that the media should engage and show concern on the issue. According to Denny (1999), the "media promotes racism by using offensive team names in newspaper headlines, television news and radio reporting" (p. 1). Thus the media support racism without knowing.

Some scholars and media critics argue that the journalistic principle of remaining objective can be difficult. "No human can be totally objective. Family, education, personal interests, religious, and political beliefs all influence how reporters cover stories and what stories they see as newsworthy" (Bender, Davenport, Drager, & Fedler, 2009, p. 136). One frequent argument against the imagery is the negative effects it has on Native and non-Native people, especially children. Opponents point out that no other ethnic group in the United States is portrayed as a mascot, and no other ethnic group would tolerate such portrayal. For some Native Americans, a sports team with an Indian mascot or logo "exacerbates a tragic American legacy of government-sanctioned genocide, bigotry, racism, and economic and political deprivation against Native American tribes" (Beadle, 2002, p. 1).

With the negative reminders that surround Native American imagery, many journalists reason media outlets should take into account their ethical responsibility. Journalists must consider whether it is ethical to use the imagery if it offends, harms, or alienates people. Journalists make these ethical decisions daily. Tim McGuire, editor of the *Minneapolis Star Tribune* said, "Journalists make hundreds of subjective decisions each week, such as choosing not to use the F word, or not calling people certain names that other people might call them or printing the names of rape victims" (NAJA, 2002, p. 1).

Opponents who work within the media have made numerous attempts towards eliminating the use of Native American athletic imagery in media. In 2002, the Native American Journalists Association (NAJA), deemed Native American athletic imagery "racist" and "offensive" (p. 1). The association asked all news organizations nationwide to stop using sports mascots and nicknames that depict Native Americans. The NAJA wanted news organizations to adopt a zero tolerance policy and end the use of the racist imagery by 2004 (NAJA, 2002).

The efforts of *The Oregonian* have received a great deal of attention. In 1992, *The Oregonian* announced that it would not use names and imagery that might offend their readers. The statement released by editor stated: "*The Oregonian* will immediately discontinue using sports teams' names and nicknames that many Americans feel are offensive to members of racial, religious, or ethnic groups. Initially, this will include references to Redskins, Redmen, Indians, and Braves" (Jensen, 1994, p. 18). According to Jensen (1994), the statement continues to state that the newspaper may drop other names if they are also considered offensive. The editor wrote the reason for the policy was "the belief that these names tend to perpetuate stereotypes that damage the dignity and self-respect of many people in our society" (p. 18).

According to Hofmann (2005), in 1993 the *Minneapolis Star Tribune* also applied a policy to discontinue the use of printing Native American imagery and to report news on teams by using the name of the

school or city.

The efforts of mass media have not only been by print media but also by broadcast. In 2001, a sportscaster in Tulsa, Oklahoma, agreed to address schools with Native American nicknames by the official school name. The sportscaster, Chris Plank, stated that he "finds the terms derogatory" and "can be offensive to a lot of people" (Wofford, 2001, p. 1). Plank's viewpoint was shared by another sportscaster, Big Al Jerkens, who also agreed not to use the term "redskin(s)" when reporting. Jensen (1994) writes that a Washington, DC, radio station had a brief ban on the use of the word "redskin" in 1992.

Himebaugh (1994) suggests journalists can help make a difference by taking steps to eliminate stereotyping problems. Journalists should take time to learn about Native American culture and the struggles that Native people face. When mainstream media report on Native Americans, they tend to focus on negative news, such as alcoholism or poverty. However, mainstream media can help by reporting on positive news as well. Native American journalists have been taking actions to eliminate stereotypes in media. The NAJA launched a campaign that "examined the best and the worst of journalism," which observed reporting on populations of color (p.2). Native Americans have also made progress regarding stereotypes by founding organizations that focus on the images of Native Americans in media. For example, Sonny Skyhawk founded the American Indians in Film, whose purpose is to "improve the image of Native Americans in motion pictures and television" (Himebaugh, 1994, p. 2).

Summary Perspective

Based on the research and literature presented, this author concludes that the media do promote racism through Native American athletic imagery. Also, some media professionals do not support those who are offended by the imagery. Racism is promoted through the media agreeing to continue the use of the derogatory and offensive imagery of Native Americans but not using offensive imagery of other races or ethnic groups. The continued racism directed at Native Americans by the media can only result in adverse and damaging effects on Native Americans and non-Natives in society. As Beadle (2002) points out, the use of Native American imagery can serve as a reminder of the difficulties Native Americans have faced throughout the country's history. The effects can demonstrate to society that it is "okay" to perceive Native Americans in a negative manner.

As journalism classes in universities teach, the media should adhere to the news value of objectivity but also the news values of ethics and avoiding stereotypes. According to Bender, Davenport, Drager, & Fedler, (2009), when the media use the imagery in stories, it consequently "demeans Native Americans by using descriptive words or phrases that cast them in a negative light. You should avoid such stereotypical words as wampum, warpath, brave and squaw" (p. 74).

To better understand my conclusion, one might consider both the framing and stereotype theories. The framing theory in media supports the idea that people use expectations to make sense of the world and can be strongly influenced by particular news sources. Research has shown that news coverage results in learning that is consistent with particular frames that structure news coverage (Nelson & Clawson, 1997; Terkildsen & Schnell, 1997). Thus, if news outlets dominate a single frame, learning will tend to be influenced by that frame. The framing theory can be applied to this argument about Native American athletic imagery because if the news portrays, or

frames, Native Americans with negative imagery, the result will be that society will view Native Americans in objectionable ways, as well.

According to DeFleur & Dennis (1994), the stereotype theory "aids in understanding how the media help perpetuate certain clusters of belief about particular categories of people" (p. 606).

The concept of stereotypes has been around for many years. One reason for this is because the media serves as a "channel" that passes stereotypes from generation to generation (DeFleur & Dennis, 2012). Mass media act as "the foundation from which meanings leading to prejudices and biases toward various categories of people can be learned" (DeFleur & Dennis, 2012, p. 598). By examining this theory, the author found that the media continuously perpetuate stereotypes of Native Americans by printing Native American athletic imagery. Because the media play a large role in society, as long as they continue to support Native American athletic imagery in news reports, society will consider this the norm. This will result in Native Americans being ostracized in society.

Conclusion

The use of Native American athletic mascots, nicknames, logos, and imagery can be a highly sensitive issue and continues to remain controversial. Based on a review of the literature, the following two conflicting viewpoints surrounding the issue become apparent: (1) Keeping this imagery honors Native people, supports nostalgic feelings, and saves funding; and (2) Keeping this imagery is offensive and degrading because it is sacred to Native Americans and perpetuates negative stereotypes. Arguments also focus on the media's actions in terms of the controversy. Some argue that the media should remain objective while others argue the media cannot be completely objective and should act ethically and take actions to support the debate.

Some actions have been taken by those who oppose the use of Native American athletic imagery in media. These actions include issuing policies against the imagery, speaking out against its use, and maintaining ethical responsibility on controversial issues. However, many people are critical of these actions because they contradict the journalistic value of objectivity. These people state the media should not take a stance on the issue of Native American athletic imagery.

This research project explored the issue of the use of Native American athletic imagery in media and attempted to answer the following question: Do the media promote racism through Native American athletic imagery or support those who are offended? This research has shown that there may not be a "perfect" answer to this question. Some argue that the media do not promote racism, society does. The media simply serve as a mirror for the world. Those who argue for some type of action against the use of this imagery argue the media can avoid possible support of racism by clearly covering this issue, other issues that concern Native Americans, and/or not using the imagery altogether. After applying the framing and stereotype theories to the issue, the author's results suggest that the media do promote racism through Native American athletic imagery. The author concludes that as long as the media continue to use Native American athletic imagery, society will continue to have a marginalized view of Native Americans.

References

Baran, S. J., & Davis, D. K. (2012). Mass communication theory: Foundations, ferment, and future. (6th ed.). Boston, MA: Wadsworth Cengage Learning.

Beadle, M. (2002, February 20). Mascot display takes aim at stereotypes. Smoky Mountain News. Retrieved from http://www.main.nc.us/wncceib/esqEXHIBITsmnews.htm

Bender, J. R., Davenport, L. D., Drager, M. W., & Fedler, F. (2009). Reporting for the Media. (9th ed.). New York City: Oxford University Press.

DeFleur, M. L., & Dennis, E. E. (1994). Understanding mass communication: A liberal arts perspective. (5th ed.). Boston, MA: Houghton Mifflin Company.

Denny, J. (1999, Sep 09). Media promotes racism by using racist names. The Circle : News from an American Indian Perspective, pp. 5-5. Retrieved from http://search.proquest.com/docview/196587914?accountid=13153

Himebaugh, G. (1994). The image never fades: A survey of tribal college presidents on media stereotyping. Tribal College, I(1), 32-32. Retrieved from http://search.proquest.com/docview/231684493?accountid=13153

Hofmann, S. (2005). The elimination of indigenous mascots, logos, and nicknames: Organizing on college campuses. American Indian Quarterly, 29(1), 156-177,354. Retrieved from http://search.proquest.com/docview/216855190?accountid=13153

Jensen, R. (1994). Banning 'Redskins' From the Sports Page: The Ethics and Politics of Native American Nicknames. Journal Of Mass Media Ethics, 9(1), 16.

Merskin, D. (1998). Sending up signals: A survey of Native American media use and representation in the mass media. Howard Journal Of Communications, 9(4), 333-345. doi:10.1080/106461798246943

NAJA calls upon news media to stop "using mascots". (2002, Mar 01). Native American Times, pp. 4B-4B. Retrieved from http://search.proquest.com/docview/367573931?accountid=13153

Native American mascots. (2008, March 6). National Collegiate Athletic Association. Retrieved from http://www.ncaa.org/wps/portal/ncaahome?WCM_GLOBAL_CONTEXT=/ncaa/NCAA/Media%20and%20Events/Press%20Room/Current%20Issues/General%20Information/native_american_mascots.html

Nelson, T. E., & Clawson, R. A. (1997). Media Framing of a Civil Liberties Conflict and Its Effect on Tolerance. American Political Science Review, 91: 567-583.

Terkildsen, N., & Schnell, F. (1997). How Media Frames Move Public Opinion: An Analysis of the Women's Movement. Political Research Quarterly, 50: 879-900.

Wofford, G. (2001, May 31). Sportscasters honor native people by not mentioning Indian mascot names. Native American Times, pp. B1-B1. Retrieved from http://search.proquest.com/docview/367619767?accountid=13153

The Ever-Changing Social Perception of Autism Spectrum Disorders in the United States

Danielle N. Martin
East Carolina University
Faculty Mentor: Michael Bassman
East Carolina University

ABSTRACT
This paper aims to examine the comprehensive social perception of autism spectrum disorders (ASDs) within the United States today. In order to study the broad public view of those with ASDs, this study investigates the evolution of the syndrome in both sociological and scientific realms. By drawing on the scientific progression of the syndrome and the mixture of this research with concurrent social issues and media representations, this study infers why such a significant amount of stigmatization has become attached to those with ASDs and how these stigmatizations have varied throughout history. After studying this evolving social perception of ASDs in the United States, the writer details suggestions for the betterment of this awareness, including boosted and specified research efforts, increased collaboration within those experts in autism, and positive visibility of those with ASDs and their families. Overall, the writer suggests that public awareness has increased and thus negative stigmatization has decreased in recent years; however, there remains much to be done to increase general social understanding of ASDs.

"Autism is about having a pure heart and being very sensitive… It is about finding a way to survive in an overwhelming, confusing world… It is about developing differently, in a different pace and with different leaps."
-Trisha Van Berkel

The identification of autism, in both sociological and scientific terms, has experienced a drastic evolution since its original definition in the early 20th century. From its original designation by Leo Kanner (1943), public understanding of autism spectrum disorders (ASDs) has been shrouded in mystery and misperception. The basic core features of all ASDs include problems with basic socialization and communication, strange intonation and facial expressions, and intense preoccupations or repetitive behaviors; however, one important aspect of what makes autism so complex is the wide variation in expression of the disorder (Lord, 2011). When comparing individuals with the same autism diagnosis, one will undoubtedly encounter many different personalities, strengths and weaknesses. This wide variability between individuals diagnosed with autism, along with the lack of basic understanding of the general public, accounts for a significant amount of social stigma in our society today. Social stigma stemming from this lack of knowledge has been reported in varying degrees since the original formation of the diagnosis. Studies conducted over the past two centuries have shown perceived negative stigma from the view of both the autistic individual and the family or caretakers

behind that individual. Concurrent with these studies on perceived stigma have also been studies on public knowledge, media representations and medical classifications. In order to understand the evolution of autism in both scientific and sociological terms, one must condense this vast amount of knowledge into one general public perception.

This body of work will aim to bring to light many of the social misconceptions tied to ASDs in the United States today, in an effort to boost understanding and evaluate the reasons for this stigmatization. Herein, the reader will find a detailed history of the scientific understanding of ASDs, ending with a description of what science now understands autism to be. Next, the reader will be introduced to current issues in social perception and the history behind this medical and social disconnect. Finally, the writer will conclude with personal suggestions.

LITERATURE REVIEW

Scientific Evolution

While the syndrome of autism was surely existent prior to its official characterization, it was not until 1912 that Swiss psychiatrist Eugen Bleuler first used the term "autistic" to describe social withdrawal observed in schizophrenic adults (Happé, 1995). In the 1912 issue of the American Journal of Insanity, Bleuler falsely described autism as another form of schizophrenia; however, his description of these individuals did somewhat mirror modern descriptions of individuals with an ASD (Syriopoulou-Deli, 2010). It was not until a 1943 edition of the journal The Nervous Child that child psychologist Leo Kanner presented his complete definition of autism as a unique disorder under his label of "early infantile autism." Kanner's 1943 paper, entitled "Autistic Disturbances of Affective Contact", aimed to characterize a set of similarly-displayed features observed in a study of eleven children. In each of these children, Kanner detected strong cognitive ability with concurrent severe social interaction difficulties, limitations in spontaneity, belated echolalia, hypersensitivity to stimuli, excellent rote memory, and a difficulty processing or adapting to change manifesting in an obsession for sameness. In his later publications, Kanner would go on to say that he perceived only two of these observed features as necessary and sufficient for the diagnosis of autism: extreme isolation and obsession on the preservation of sameness. One specifically crucial discovery by Kanner was that of the autism spectrum, or the concept that autism varied significantly between and within diagnosed individuals. He noted in his samples that ASDs were manifested in extremely varying fashions between individuals, with no two individuals expressing identical developmental strengths and weaknesses. Kanner also described how autism as a condition continued to evolve throughout the lifetime of each individual (Happé, 1995). While Kanner was the first to describe autism as an independent disorder, it has been found subsequently that his definition was still limited and thus insufficient.

Following this definition by Kanner came a flood of new research on the autism spectrum. In 1944, only one year after the original definition of the disorder, Hans Asperger published his work on childhood "autistic psychopathy"; however, this work would not become well known until its translation into English in 1997 (Syriopoulou-Deli, 2010). In a fashion similar to Kanner, Asperger described severe social withdrawal, obsession with routine or sameness, and individualized interests which often became additional obsessions. In comparison to the previous subjects studied by Kanner, however, these

new participants expressed significantly better socialization and communication skills. Asperger's Syndrome—as the term was defined by Lorna Wing in 1981—could then be employed to describe those who existed on the high-performing end of the spectrum, and whose difficulties were less severe than those with the straight diagnosis of autism (Happé, 1995). Since its introduction, guidelines concerning an Asperger's diagnosis have been constantly challenged, with correct categorization as the main point of consternation (Syriopoulou-Deli, 2010). With this further categorization of individuals, understanding of autism was made both more complete and more complex.

It was in later papers of 1956 and 1967 that prominent educator and psychiatrist Bruno Bettelheim, in an attempt to explain away the confusion enshrouding ASDs, introduced his "refrigerator mother" theory. This theory, which was discredited following later scientific study, hypothesized that autism in children was developed as a response to a dangerous and unloving environment created specifically by the child's mother. He described these children as "solipsistic as infants in their contact with reality," and in his view this condition was solely a psychological issue that could be reversed with intense therapy for both mother and child. This hypothesis was officially discredited after the medical field as a whole shifted from pure psychological review to more biologically-based psychological studies of autism; however, following this shift, society as a whole has continued to struggle with the concept of autism as a purely medical condition (Syriopoulou-Deli, 2010). Bettelheim's original studies introduced a great deal of misunderstanding into the public eye, as well as confusion about the causes and foundations of autism.

A significant increase in biologically-based studies attempting to find the genetic, neurological or environmental basis of autism was seen after this post-Bettelheim shift in the late 20th century; however, the uncertainty surrounding this biological basis caused a definite split in the scientific community of the time. The influential study by Folstein and Rutter, published in 1977, first introduced autism as a specifically genetically-based disorder. Following studies by Rutter and Schopler, published in 1986, looked further into the frequency of the fragile X syndrome in autistic individuals, which is an abnormality in the X chromosome that largely affects males. In 1987, Karandanos examined the idea that autism and mental deficiency were not synonymous, and are caused by different neuropathological issues. Discerning this biological basis, however, has always been difficult, as ASDs vary so significantly between individuals. Darby (1976) and Williams (1980) addressed the issue of secondary complications and were unable to provide a sufficient biological explanation (Syriopoulou-Deli, 2010). While the search for a biological basis of ASDs has continued on to the present, research findings are both convoluted and insufficient.

While the search for a sufficient biological explanation has yet to come to fruition, this multitude of studies has led to a better-accepted and more complete definition of ASDs. Increased understanding has encouraged a transition from perceiving those with autism as mentally ill or dangerous to viewing them as special-needs individuals. It is now generally understood in the scientific community that autism is not a medical issue that may be cured; rather, it is a disorder marked by display of certain social characteristics. The establishment of this strong research base has also helped to create a set of criteria for the diagnosis of autism. Through statistical-epidemiological research, Lorna Wing and Judith Gould (1979,

1996) defined the basis of autism as "an obvious divergence from the expected socially correct behavior, independent of their mental and cognitive status." In an evolution from Kanner's earlier statements, Wing and Gould also introduced the idea of an "autistic continuum" that remains the accepted theory (Syriopoulou-Deli, 2010). These ideas remain the basis for autism identification and diagnosis.

Through this body of study, the current criteria for the evaluation and diagnosis of autism have been detailed. Generally known as Wing's triad of impairments, three fundamental impairments exist at different stages of development that are necessary and sufficient for an ASD diagnosis. These three impairments lie in the areas of social interaction, imagination and communication. It is extremely common for individuals to display some sort of repetitive behavior pattern in addition to these three impairments; however, this behavior is not necessary in order to classify an individual as autistic. It is now widely understood that each individual is affected differently by autism; some may experience learning disabilities, while approximately 10% develop savant skills in specific areas. Other secondary characteristics include language difficulties, issues with motor skills, abnormal physical development or function, inappropriate emotional reactions, and hypersensitivity to sensory stimuli. It is also common for autism to co-occur with a variety of other disorders including epilepsy, attention deficit disorder and Down syndrome (Bogdashina, 2006). At this time, there are two internationally-employed and standardized diagnostic tools: the World Health Organization's International Classification of Diseases, 10th edition (ICD-10) and the American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders, 5th edition (DSM-V). These standardized diagnostic tools, in conjunction with an increased understanding of what autism is and is not, have allowed for significant recent progress in the autistic community; however, stigma toward these individuals in the United States has far from disappeared (Bogdashina, 2006).

Social Evolution

The steady scientific evolution of ASDs has been paralleled with a simultaneous evolution in social perception and stigmatization. Stigmatized persons, as defined in 2009 by Oren Shtayermman, are those "who possess a quality that others perceive as negative, unfavorable, or in some way unacceptable." Stigmatization of those with developmental disabilities has always been common, as it is human nature to judge those who are noticeably different, with severity of this judgment and stigmatization typically increasing with severity of the condition (Shtayermman, 2009). Since the original definition of ASDs, those on the spectrum and their families have been have been challenged by stereotypes. The numerous reasons for this associated stigma include the individualized nature of the syndrome, the associated different speech and actions, and the lack of understanding in its physical basis. This stigmatization is made worse due to the inability of many autistic individuals to express their thoughts or emotions to neurotypicals.

A dramatic evolution in social perception may be seen while studying the history of autism study in the United States; however, there exists a common thread of social challenges that have been reported by autistic individuals of all ages at all points in history. The most prominent of these common experiences is arguably the recognized extreme feelings of isolation extending from childhood to adulthood, with many individuals reporting increased feelings of isolation as they grew older due to increased self-awareness and installment

of stigma in the minds of peers. The reactions to these feelings of isolation understandably vary widely between individuals, with some attempting to accept these feelings of loneliness and others attempting to improve relationships with their peers. Again, it may be seen that the amount of improvement on these existing relationships will vary significantly from case to case, depending on a wide range of factors such as environment, intensity of impairment, and personality of the autistic individual (Müller, Schuler, & Yates, 2008). These feelings of isolation are also intrinsically connected to the amount of stigmatization that an autistic individual receives from those in the surrounding environment. Studies have shown that sense of stigmatization felt by those with an ASD is directly linked to their self-esteem, as those who perceive a greater amount of stigmatization have lower self-esteem (Shtayermman, 2009). One suggestion for this relationship was presented by Martz in 2004, who hypothesized that those with developmental disabilities such as an ASD may internalize outside stigmas placed upon them by peers (Shtayermman, 2009). Combating these feelings of isolation and stigmatization is an extremely difficult challenge for many on the spectrum, as they are also faced with a multitude of additional impairments which act as an unlimited source of personal challenges.

Subsets of autistic individuals have reported additional personal challenges including, but not limited to: difficulty initiating and maintaining communication, issues building relationships, and combating the preconceived notions of peers. Communication is, on a very basic level, an aspect of daily life that many neurotypical individuals take for granted; however, it is a point of constant consternation for those with an ASD. Difficulty initiating conversation is often reported as the most difficult aspect of communication, as autistic individuals often either lack the understanding of how to initiate conversation or the self-confidence to approach a communicative situation. Continuing communication after initiation is similarly difficult, as participating in unstructured dialogue and understanding the implicit meanings behind verbal messages can be extremely confusing. In addition to the basic lack of understanding, communicating is made more difficult when one includes the more subtle behaviors that are involved in communication as well. These subtle behaviors include facial expressions, hand gestures, and tone of voice (Müller, Schuler, & Yates, 2008). All of these factors together create an outline for conversation that is infinitely more complicated than it may seem to a neurotypical individual.

These feelings of isolation, intensified by the described communication barriers, create an understandable longing for intimacy in many autistic individuals; however, this intimacy is again difficult to build and maintain. While it is often the wish of an autistic individual to become more emotionally and physically connected with another person, the basic limits of his/her own tolerance for emotional probing and physical touch become a fundamental problem. Then, it may be understood that it becomes important to develop relationships that are fulfilling yet still leave a significant amount of personal space—both physically and emotionally (Müller, Schuler, & Yates, 2008). Through these results by autistic individuals, a sense of severe loneliness and struggle may be felt, because of this difficulty in emotional connection.

The intensity of these social challenges, both individually and holistically, is determined in a large part by the environment and individuals that an autistic individual encounters on a daily basis. In considering what creates this complete and

immersive social environment, one must consider the understanding of ASDs that permeates throughout that environment and the preconceived notions or stigmatizations that combat comprehension of new education or research. All of these factors together create a social perception of autism that is undeniably community-based yet varies widely between individuals. In order to understand the current social perception of ASDs in the United States as a whole, one must first examine the history and evolution of autism-based stigma.

The association of negative stigmatization with ASDs began with Eugene Bleuler's use of the word "autistic" to describe social withdrawal in schizophrenic patients. This original terminology assigned a decidedly negative connotation to the word. Re-use of the term by Kanner and Asperger roughly thirty years later to describe a completely new syndrome encouraged this negative connotation to transfer more generally to all of those individuals with an ASD. Introducing this new syndrome as almost an outcropping of schizophrenia, a disorder that is so negatively perceived in the public eye, set those with autism at an immediate social disadvantage. A large dose of public intrigue was added with the subsequent confusion concerning nearly every aspect of ASDs. Together, these two factors have provided a basis for public confusion and creation of an overall negative social perception of autism.

Following the original classification of autism as an individual disorder by Kanner in his landmark paper of 1943, a wide range of theories concerning the basis of autism were expressed. Initial research was based in the field of psychology, and focused specifically on identifying the basic cause of the syndrome in order to isolate means of prevention, early identification, and continuing treatment (Syriopoulou-Deli, 2010). As the condition was initially considered to be founded in the psychological rather than physical realm, it can be understood that Bruno Bettelheim was the first individual to propose a possible basis for the syndrome. Bettelheim introduced the psychogenic myth, which suggested that the "refrigerator mother" was the cause of autism. His refrigerator mother theory suggested that autism in children was simply a maladaptive response to a hostile and unloving environment created by the child's parents, with more emphasis placed on the parenting styles of the mother. In Bettelheim's view, the mother was herself in need of severe psychological treatment, and in many cases the child was removed from the mother's care. While this theory has since been discredited, the ideals associated with the psychogenic myth remain a challenge to the families of autistic individuals today. In addition, it may be seen in parts of Europe that this belief holds precedence over more recent scientific advances (Happé, 1995). It may be initially difficult to understand how this suggestion could be so widely accepted in the scientific and public realms; however, when one considers the social challenges of the time, it is much more easily understood. At this point in history, the United States was in an extreme transition point following World War II. During this time, women in some regions were integrated into the work force for the first time in United States history, and this shift was cause for strong opposition by more conservative individuals (Syriopoulou-Deli, 2010). This opposition made acceptance of the refrigerator mother theory more understandable. Here, one may witness the first example of how broad social perception of autism in the United States was undeniably influenced by the environment of the time.

In following years, a shift from Bettelheim's refrigerator mother theory was seen along with a simultaneous shift in the scientific realm as a whole. During this time, the study of autism progressed from

a hypothetically psychologically-based syndrome to one with a both biological and environmental basis. Since the mid-twentieth century, a significant increase in these biologically-based studies has been observed; however, doubts remained that autism could be considered solely biologically-based. The search for a biological basis has become seemingly more convoluted over time and remains to be elucidated. Simply identifying the condition was difficult in itself, as there are significant variations between the type and intensity of impairments in autistic individuals (Syriopoulou-Deli, 2010). This continuing amount of doubt, paired with the inability of the scientific community to define a biological basis for the condition, has fueled a significant amount of media attention and public bewilderment.

Media portrayal of ASDs is an extremely important facet to consider when attempting to define public perception of those with autism. The original media tropes created during the time of Bettelheim's dominance have persisted despite the increase in overall understanding. This shift is due to the persistent flux of media attention that is largely created by people who are themselves neurotypical. According to the 2011 study by Sarrett, media attention throughout the years has consistently focused on the fragmentation and imprisonment of autistic individuals, specifically autistic children. These themes have worked to introduce an additional level of mystery into the public eye, along with a sense of sadness for the fragmented human being. Undoubtedly, this media attention both creates new stereotypes and reinforces existing ones in the realm of the general public. Thus, the media impacts how the public interacts with those who are diagnosed with a disability such as an ASD. The theme of fragmentation is apparent within media representations on a variety of levels. In the most apparent sense, the autistic individual is often represented as being somehow "less than whole" with a fragmented mental health and personality. On a more obtuse level, autism is represented as something that will fragment a family and even the surrounding community. More recent studies on autistic families have reinforced these ideas, as they have shown high divorce rates and familial stress in families with one or more autistic child. Fragmentation themes originated during the time of Bettelheim and the psychogenic myth, when those experts on autism believed that autistic people were somehow broken or fragmented due to their condition (Sarrett, 2011). The theme of imprisonment of the autistic individual has also been commonly presented to the public. In this view, it is generally believed that a normal, neurotypical person is somehow trapped in an autistic shell of a body. Many of these depictions instill in viewers an urgent need to assist with releasing the individual from the confines of autism. This idea is intensified by an additional commonly-seen media trope of utter unawareness of self and others in the autistic person (Sarrett, 2011). Most recently, the media emphasis has been placed on the rise in rates of autism diagnoses and the idea of a possible autism "epidemic". Again, it may be seen that the media attempts to highlight the most publicly enticing details or concepts behind ASDs (Sarrett, 2011). With this relatively prominent idea of an autism epidemic paired with a lack of education concerning the syndrome throughout the general public, it is understandable that the negative connotations and social stigmatizations associated with autism persist in today's society.

Discussion

After understanding the history behind the scientific and social evolution of autism as an independent syndrome, one begins to see that there may be ways to foster a

more tolerant and open understanding of those with autism in the United States today. A first step would include successful management of the syndrome. In order to ensure the successful treatment of an ASD, and to provide the best quality of life possible, a collaborative effort between all components of the health care team is essential. This collaborative effort should include clinicians, teachers, school workers, agents from outside support groups or foundations, the family, and the autistic individuals themselves (Quirantes, 2009). It is only through a strong and dynamic support system such as this that an autistic individual may truly strive in today's world. This open support and communication between all members also fosters a caring sentiment that promotes patience and adaptability in the team members. A willingness to adapt to the needs of each individual autistic child or adult is essential for those who wish to work with them, as the needs and personality of each autistic individual vary so significantly.

As research continues to move forward, it is equally important that a collaborative relationship is fostered between clinicians and researchers. Improvements must be made in each of these individual fields if significant future advances are to be made. Within the field of scientific research, specifically epidemiological studies, researchers should be pushed to identify social biases that could impact the population study samples, and to question how many children remain undiagnosed within each community. Researchers should also aim to study the syndrome across a range of communities and cultures, as comparative social bias and diagnoses range significantly (Lord, 2011). On a clinical level, education levels must be boosted in all health care providers concerning mental disabilities such as ASDs. Large organizations such as Autism Speaks and the Autism Society have worked to increase awareness for many years; however, the knowledge-base on ASDs in health care providers remains very low (Quirantes, 2009). While it is important for these health care providers to continue education on the general premises of autism, the application of this knowledge is arguably more important; therefore, it may also be concluded that methods of screening and treating autism should be improved as well. According to the American Academy of Pediatrics, it is important that children are screened for autism frequently and at a young age, so that children may begin to receive intervention services ideally before the age of 3 (Warren et al., 2011). In order to promote this early childhood screening, the American Academy of Pediatrics developed several new strategies for the identification of autistic children by pediatricians (Johnson & Myers, 2007). Within these strategies, it was suggested that once a child had been identified as at-risk for developing an ASD, a formal screening tool such as CHAT (Checklist for Autism in Toddlers), ITC (Infant-Toddler Checklist) or M-CHAT (Modified Checklist for Autism in Toddlers) should be employed. Without formal screening tools such as these, physicians are forced to rely solely on clinical impressions and have a much higher chance of misdiagnosis; however, it remains that only approximately 8% of pediatricians screen for ASDs on a regular basis (Quirantes, 2009). Another significant challenge for health care providers is diagnosing ASDs in children from ethnic minority groups, specifically those whose primary language is different from that of the physician. This difficulty is reflected in the current under-representation of minorities in mental health facilities and other support organizations. These low diagnostic rates in minorities are possibly due to actual lower rates of ASDs; however, studies have shown that this discrepancy is more likely

due to the failure of physicians to generate a correct diagnosis. Forming an adequate clinical judgment on children from many ethnic minorities may prove difficult to many physicians, due to discrepancies in familial background or socio-economic status. Due to this mutual lack of understanding and communication, it has been seen that physicians are less likely to screen for ASDs in children from certain minority groups (Begeer et al., 2009). By increasing the rates of appropriate diagnosis through adequate usage of diagnostic tools, quality of care for autistic individuals may be significantly increased and more accurate rates of autism within communities determined (Quirantes, 2009). In this consideration, health care providers must take on the role of both advocate and support system.

While the importance of increased communication, more comprehensive research aims, and improved physician care should not be undersold, many consider the evolution of better social perception for autistic individuals the most important future progression. The social image of autism has improved dramatically since the creation of groups such as the US Autism and Asperger Association, National Autism Association, Autism Society, and Autism Speaks. These groups have worked to support ongoing scientific and sociological research, provide resources for health care providers and caregivers, and strive for an increase in overall quality of life for autistic individuals. Support services such as these have also played an important role in educating the general public on the intricacies of autism, and therefore in improving the general image of autism in the eye of society. Even more importantly, these groups have provided a safe outlet for the mixing of autistic individuals and their caregivers, which has prompted a significant increase in the numbers of autistic individuals speaking out to the public. The importance of this increase in autistic voices cannot be stressed enough, as they are truly the key to understanding the needs and emotions associated with ASDs. These public statements given by autistic individuals and their families work to counteract the current stigmatization and negative social perception that are so prominent in the United States today (Müller, Schuler, & Yates, 2008). Open narratives of life with autism are often particularly informative and communicative, as they present a comprehensive new perspective and challenge the reader to forgo pervious assumptions created by misunderstanding or media representations. This open communication stream flowing from many autistic individuals continues to be challenged by the silence of those that cannot or will not communicate, as this inconsistency brings questions about the generalizability of these autistic narratives; however, these new publications have driven the media to portray ASDs in a different light, as it presents a new face of autism to the general public (Sarrett, 2011). From the aforementioned statements, it may be suggested that an even further increase in autistic accounts is critical for the continued improvement of social perception of autism in the United States.

CONCLUSIONS

After considering the body of work that displays a history of misrepresentation and confusion regarding autism, one may easily understand the reasons behind the negative social perception which enshrouds the syndrome today; however, movement toward a more positive view is both tangible and promising. After decades of confusion concerning the origin of ASDs—be it biological, psychological or environmental—the American public has been concurrently intrigued and baffled

by the condition; however, recent scientific breakthroughs paired with an increase in autistic voices has worked to combat this bafflement. While a significant amount of public relations work remains to be done, and many improvements are needed in all aspect of autistic care and treatment, it may be suggested that the social perception of autism has improved significantly since Kanner's 1943 description and Bettelheim's following theories. This research suggests that this boost in understanding and social awareness should continue to improve with greater public understanding of ASDs and continuing research to elucidate the foundations of the disorder.

References

Begeer, S., El Bouk, S., Boussaid, W., Terwogt, M., & Koot, H. M. (2009). Underdiagnosis and referral bias of autism in ethnic minorities. Journal of Autism and Developmental Disorders, 39(1), 142-148.

Bogdashina, O. (2006). Theory of Mind and the Triad of Perspectives on Autism and Asperger Syndrome. Philadelphia, PA: Jessica Kingsley Publishers.

Happé, F. (1995). Autism: an introduction to psychological theory. Cambridge, MA: Harvard University Press.

Johnson, C.P., & Myers, S.M. (2007). Identification and Evaluation of Children with Autism Spectrum Disorders. Pediatrics, 120(5), 1183-1215.

Lipsky, D., & Richards, W. (2009) Managing Metldowns: Using the S.C.A.R.E.D. Calming Technique with Children and Adults with Autism. Philadelphia, PA: Jessica Kinglsey Publishers.

Lord, C. (2011). How common is autism? Nature, 474, 166-168.

Müller, E., Schuler, A., & Yates, G.B. (2008). Social challenges and supports from the perspective of individuals with Asperger syndrome and other autism spectrum disabilities. Autism, 12, 173-190.

Quirantes, D. (2009). Collaborative Approach to Autism: A Parent's Perspective. Journal for Specialists in Pediatric Nursing, 14(3), 203-205.

Sarrett, J. C. (2011). Trapped children: Popular images of children with autism in the 1960s and 2000s. Journal Of Medical Humanities, 32(2), 141-153.

Shtayermman, O. (2009). An exploratory study of the stigma associated with a diagnosis of Asperger's syndrome: the mental health impact on the adolescents and young adults diagnosed with a disability with a social nature. Journal of Human Behavior in the Social Environment, 19, 298-313.

Syriopoulou-Deli, C. K. (2010). Autism: Sociological Perspectives. Interdisciplinary Journal of Contemporary Research in Business, 2(1), 118-131.

Warren, Z., McPheeters, M., Sathe, N, Foss-Feig, J., Glasser, A., Veenstra-VanderWeele, J. (2011). A systematic review of early intensive intervention for autism spectrum disorders. Pediatrics, 127, 1303-1311.

The Role of Formal and Informal Support in the Decision to Return to New Orleans after Hurricane Katrina

Nicholson Sprinkle
with **Latosha Adams**
University of North Carolina at Greensboro
Faculty Mentors: Eric Jones and Arthur Murphy
University of North Carolina at Greensboro

ABSTRACT
Hurricane Katrina made landfall in New Orleans, Louisiana, on August 29, 2005. Seven years later, the effects of the storm can still be seen in the city and its culture.Walking in the lively downtown atmosphere of Bourbon Street, listening to the Jazz and sampling the best gumbo in the city, it would be easy to assume a hurricane had never come through; it would be easy to assume that no one had been forced to flee from their homes or huddle in the Superdome and wait for outside assistance. It is not until one travels out of the sprawling downtown district and the lovely French Quarter, past affluent neighborhoods, and into the middle to lower class neighborhoods that Katrina's mark is so plainly seen. Down unkempt roads with massive potholes and cracked sidewalks that belie the flat terrain, occupied houses at different levels of repair sit next to their silent, empty neighbors. Some of the uninhabited houses still bear the 'X' marking that offers details about the search and rescue efforts – how many inside were found alive or dead and in what rooms.The people, like their houses, are in varying stages of repair seven years after the storm.At the end of the day, there is only one true universal among these inhabitants, many of whom returned to their previous houses-none of these people are living in the same neighborhoods as before the storm. Such is the state of the St. Anthony neighborhood of New Orleans.

The storm's devastation brought disastrous conditions literally through people's front doors, with some interviewees reporting that polluted water reaches as high as eight feet inside their houses. Once it came, it sat in their homes and neighborhoods for days, destroying houses, valuables, and heirlooms before finally draining out of the neighborhoods. Slowly, after weeks of waiting, the displaced inhabitants of St. Anthony were allowed into their neighborhood to confront the mud-dominated world that used to be their home. Interviewees described the world around them as completely brown, with all plant life gone, and houses unrecognizable. The physical neighborhood they knew was now a vacant lot that would hold different outcomes for each individual. Some had the resources, both financially and socially, to overcome their losses- albeit with much hard work and determination. The lucky ones were able to attain some semblance of their life before the storm. Others reported losing everything. To meet their basic needs, some of these people accumulated high amounts of debt. And in one extreme case, an interviewee was able to regain all his physical possessions and entirely repair his home but, being in the later years of his life, lost all ties with friends, family, and former neighbors. In his own words, he was left completely isolated and "desperately alone."

Hardship, then, seems to have gone hand

in hand with returning to St. Anthony and rebuilding. But people returned in some part because of the help they got along the way from friends, family, neighbors, and governmental and non-governmental institutions. Thus, the broader questions motivating this paper are: why did these people return to this neighborhood, what keeps them in the neighborhood, and how do family, friends, formal institutions, evacuation experiences, other resources, and a sense of belonging to a place factor into these decisions? This manuscript is an exploration of how these sources of support—good, bad and otherwise—are brought to bear in the re-creation of place.

A Framework for the Study of Support and Commitment to Place Post-Recovery

Pieces of this puzzle can be found in past literature, particularly in relation to the importance of financial support evacuees receive after disasters. For example, a previous study discovered a substantial disconnect between the expected level of assistance from family and friends pre-disaster, and the reality of financial assistance after the disaster (Kaniasty, Norms & Murrell, 1990). Personal networks, then, are likely important for reasons other than "What can they give me, tangibly?"

Tangible benefits are certainly important, but not always or at least not only what evacuees and survivors need. Mental health is often affected post-disaster, with many individuals developing post-traumatic stress disorder (e.g., Rhodes et al, 2010). Studies conducted on areas impacted by the Exxon Valdez and BP oil spills, which includes Louisiana, echo this sentiment. In these studies, a relationship was found between stress from the events and economic loss, in addition to concern about family and worries about further economic loss (Gill, Picou & Ritchie, 2011). Although aversive, it is easy enough to imagine being forced from one's home, not knowing when to return, and knowing that the only thing one can come back to is a muddy shell of what used to contain so many memories. It is likely that one of the things that returnees wanted, or needed, to counter these stressors was some form of comfort that only home can provide. The effects of being engaged in one's home atmosphere have been linked to increased life satisfaction, lower rates of depression, and lower rates of stress when individuals are in situations that interrupt their personal activities are interrupted (Wakui, Tomoko, Agree, & Kai 2012). These benefits are essential during such trying times as recovery, especially because the risk of post-traumatic stress disorder can be increased by low socio-economic status (Suar, 2004), although Jones et al. (2011) found only a weak relation between socio-economic status and post-disaster mental health in Mexico after controlling for social support. Thus, directly through lack of resources, or indirectly through fractured or resource-poor social networks, interviewees can lose protective factors for mental health with the loss of possessions or with the accumulation of debt.

Previous research provides the possibility that the quality of assistance at evacuation sites impacted individuals' decisions to stay or go; aid was available from many sources at the locations studied. Welfare programs, food banks, and other nongovernmental organizations aided the displaced (Lein, Angel, Bell & Beausoleil 2009). However, the vast number of sources and lack of centralized access led to a complexity that required a substantial investment of time and energy to prove fruitful for impoverished families. Further, as Lein et al. note (2009), as the level of damage created a longer-term evacuation for many individuals, poverty assistance programs

were unsatisfactory as they "provide minimal assistance in addressing longer-term needs for education, training, job placement, and stable housing." Combined with evacuees facing "a new institutional and social environment," they ultimately were in a situation that lacked both "material and social resources."

Aside from the possible emotional and social benefits of being home, overall outlook on life has also been shown to be predicted by social support in previous studies. The attitude of many of the respondents will be discussed later in the paper, and studies have shown that individuals who have been through similar events, such as a severe flood in Poland, have their post-disaster attitudes and social cohesion impacted by the perceived quality of social support seen immediately post-disaster (Kaniasty, 2011). Altruistic communities that offered high levels of social support immediately after the flood recorded favorable appraisals of community relationships twenty months after the flood, and Kaniasty found that communities that offered less emotional support indicated less community well-being.

Finally, in looking at what makes a location worth coming back to, the idea of 'space vs. place' should be considered. The terms, while often used interchangeably, are often used to indicate the difference between a simple location and a meaningful spot--a home, an area with fond memories, or at least somewhere with a familiar or important vibe. Margaret Livingstone's (2007) essay "Sense of Place" examines the question of "What makes a place," but with a twist that we can find particularly helpful: what makes a place when the location has been destroyed by a disaster, with all physical indications of the 'place' gone forever? Memories, faith and, community are noted as the important factors, even when physical possessions (including houses) are gone.

Study Site and Setting

The site that we selected to study the importance of formal and informal resources on one's sense of space vs. place and the decision to return was St. Anthony, a neighborhood in New Orleans. St. Anthony is a neighborhood much like any of the others in New Orleans. It is flat, had a 2000 or pre-Katrina population of 5,318 residents (Greater New Orleans Community Data Center, 2012) who were spread out across its 1.6 square kilometer area, and is bordered by three streets (Elysian Fields Avenue, New York Street, and Mirabeau Street) and a canal (the London Avenue Canal) to the west. The inhabitants in my interviews describe it as having been a predominantly lower middle-class and middle class neighborhood. St. Anthony is set in the Gentilly section of New Orleans, abutting the southern edge of the University of New Orleans and close to a beautiful view of the Mississippi river. After Hurricane Katrina, the neighborhood is now a mixture of abandoned houses, repaired houses, and houses in every state in-between. In one section, there is a pristine park with slides, monkey bars, and swings next to some artificial hills created for children to play on. In the middle of the playground is a sign bearing gang-related graffiti, a reminder of one of the problems that concern the inhabitants of St. Anthony: crime.

Still, it would be erroneous to imply that each interviewee lives in fear, huddled inside their houses with blinds drawn to hide from their neighbors. During the day the streets are still occupied by the occasional man or woman walking their dog, enjoying the fresh, warm Louisiana air. The occasional group of pre-teens and teenagers, enjoying each other's company after school, can be seen milling about the newer, greener areas of their once uniform neighborhood. Intra-community activity is

still visible, though likely not as much as before the storm. As of 2010 census, the area had a population equaling 66 percent of pre-disaster St. Anthony (Greater New Orleans Community Data Center, 2012). The result of this is fewer houses and people, giving the neighborhood what some interviewees described as an "empty feeling." However, one positive result of this is the increased green space. Some abandoned lots have been purchased very cheaply by adjoining owners, with the city giving the stipulation that the owners do something constructive such as making a manicured lawn or a garden with the area. Many of the houses have done this, giving Gentilly generally, and St. Anthony specifically, a more open feel. Combined with the old ruins of houses being overtaken by grass, vines, and other greenery, this almost gives the neighborhood a different aesthetic.

As sunset approaches, the figures do recede into their homes, and interviewees are quick to offer caution. "Don't stray too far," or "don't be out past dark" are the orders of sundown, and genuine concern for our safety can be seen on interviewees' faces as they tell us this.

Methodology

Research was conducted within the neighborhood of St. Anthony, New Orleans, over three trips. The first trip involved structured surveys with sixty people in late 2008 using a random sample that was geographically stratified to cover the entire neighborhood, and was focused upon services that people solicited after the hurricane, the nature of people's personal networks, and physical health and mental health both pre- and post-Katrina. The examined data revealed a positive correlation—both financial reimbursements and emotional support correlated positively with the distance between ego (the person interviewed) and their network members (their friends and families and acquaintances that came to mind), as well as between those forms of support and the distances between those network members, signifying the actual spatial spread of the network.

This lead to a second, smaller round of interviews conducted over the course of four days in June 2011 in which twelve individuals (not from the original 60 due to the random selection) in St. Anthony participated in semi-structured interviews, including an invitation to tell their stories in a free-form narrative. The sample selection was via a geographically stratified random sample, by starting at each of the four corners of the neighborhood, Northeast, Northwest, Southeast, and Southwest, and working in a zigzag pattern towards the center of the neighborhood. Each house on a block was offered a chance to participate in an interview, and each time a house responded, we would move on and begin the next section. Roughly one in six households that we contacted allowed us to interview. Questions in the interview inquired about assistance received, from what sources, and the distance that the sources lived from the interviewee, and if the sources were family or friends. The interviews each lasted roughly half an hour, and in some cases interviewees called upon other members of their household, or even neighbors, to expound upon their experiences. The interviews were written down by one interviewer, while the other continued conversation. When given permission, the interviews were recorded on tape. Answers to the specific questions plus information from the narratives provided were taken and coded. The results from these interviews indicated that those who left the city and stayed with a friend or family member in their wide-spread social network, they were much more likely to receive formal reimbursement, namely,

insurance money. The question, then, is: why is this so? A hypothesis was formed: perhaps it is simply being away from all of the chaos, combined with the sense of being taken care of, that allows people to clear their heads enough to navigate the maze of red tape that is insurance or government assistance in a disaster scenario?

The results in this manuscript are largely based on the third and final set of interviews. The third questionnaire was drafted, and we conducted a final round of interviews in St. Anthony during a week in February and March of 2012 (see Appendix for interview guide). The purpose of these interviews was to ascertain the importance of friends, family, and the feeling of being taken care of in the midst of a crisis. Ultimately, however, it was the narratives--the stories that each person wanted to tell in addition to the questions which were asked—that revealed the most about the story of St. Anthony. The goal of this third excursion was not to gain a random sample, but simply to obtain as many interviews as possible. Each street of St. Anthony was walked down, and each occupied house was offered the chance to participate in our interview. Twenty-five interviews were completed—two were conducted as household interviews, the rest with individuals. Each gave permission to be interviewed and to have their stories published, so long as their last names were not used.

As mentioned earlier, people were asked to detail the importance of their friends, family, and the feeling of being taken care of during their crisis. The interviews began with an inquiry as to how the hurricane changed their families' interactions, if at all. This was followed by a series basic, open-ended questions: what type of assistance was given during the storm, who gave it, where the providers live, if contact is still maintained with these individuals, and if a sense of being taken cared of was felt in the aftermath of the storm.

The interviewees were encouraged to give as much detail as they wished during these answers. The range of stories and emotions were remarkable--suspicion, discontent, fear, hope, compassion, concern, awe—each person had a new piece of the story to tell about that fall of 2005, and the reconstruction, of St. Anthony. The overarching storyline for each person was unique, as were the feelings and reasons behind their return. When asked about his experiences, one individual summed up the entirety of the story: "I would like to tell [you all my story], but you ain't gonna believe none of it."

Results

We present the results of the semi-structured interviews from the latter two waves of interviews in terms of four main themes: family, friends, community, and institutional support. These were the consistent themes in the interviewees' narratives throughout both waves of the interviews about what their return was like.

Family

Family was a big part of the recovery process and, after Katrina struck, many of the victims relocated to places where family resided. The most common places were other parts of Louisiana, Alabama, Mississippi, and Texas. Everyone who said they received help from family said they were also given a place to stay by them which ranged from a few weeks to several months. Family, which included in-laws, offered the most assistance during the initial period after the hurricane hit, but then most of the people of New Orleans were left to fend largely for themselves and rebuild. Those few people who did not rely on any family shared feelings of helplessness and loneliness because they didn't feel as adequately taken care of.

Some of the interviewees stated they either did not have family who wanted to help, or their family members lived too far away to temporarily assist them. Those who had a broad sense of social networks that included family showed feelings of hope in the earlier stages. This seemed to make for an easier transition towards receiving help. In one interview, a 25 year-old woman said she stayed at her uncle's Navy Base in Texas and the military gave her and her immediate family a place to stay and substantial support. The family members who aided the people in the St. Anthony area consisted of relatives who had already been in regular contact with them. What was assessed from the data on family was that family ties did not strengthen much following the hurricane. Most shared similar responses like, "We were always close" and, "I still keep in touch with them the same way I did before the storm."

Family members who offered assistance were generally talked about in a positive light, providing a safety net very suddenly. Most family members gave what they could; this consisted of money and clothes. Despite our prodding, there was hardly any elaboration on what specifically people received from family, except for those who received a surprisingly large amount or nothing at all. One woman, in her mid-40s, had received a couple thousand dollars from her cousins. Her family also worked within their community in Florida to raise awareness about their situation and sent over clothes they had collected from volunteers and family friends. However, one gentleman, Joe, recalled his only living relative, his brother, and his refusal to acknowledge or help him. Joe, who was 71 years of age, stated:

"My entire family is gone. I have one brother who lived in New Orleans during the storm. He isn't a millionaire but he has money. He didn't call me after the storm to ask where I was or where I was going… After the storm he took off for Tampa, Florida where his wife's family lives. I didn't get a word from him. I called and he said he did have my phone number. After that I didn't hear from him in a year and a half—no holidays, no birthdays. I drove down 4 hours to his job. He saw me but he kept working. I was devastated. He was the only person I had left who was blood related..My brother didn't come by the house or tell me people were looking for me."

Joe was the only interviewee who had a distinctively negative experience with a member of his family, which affected how he perceives his family since Katrina hit. Family was an integral part of the disaster recovery process. If family was not offering assistance by means of living space, clothes, or money, they were there for emotional support. Many families travelled together, instead of parting in different directions. Extended families from the middle-class St. Anthony area would load up cars, and drive together to a state where they had other relatives or friends. It was common for extended families to live close to one another, small households would reside within blocks of grandparents as well as aunts and uncles. The surrounding neighborhoods of New Orleans parish were familiar territory and a comfort zone to the interviewees. These tight-knit families in New Orleans remained close even if other relatives decided to relocate elsewhere permanently. Families kept in contact, and they respected a relative's decision to leave, because it meant being someplace more prosperous. Those who chose to return did so out of comfort and attachment. When asked questions about family assistance, a majority of the interviewees did not talk about them in much depth unless asked more involved questions. Answers such as, "Yes, my family helped me," and "No, I didn't receive any help from any family in Tennessee" showed that they did not feel inclined to share any resentment, or vice versa.

Any help at all, from any family was well received.

Friends

The topic of friends reached broader limits than family, because friends were there for many of the people in St. Anthony before the storm, they made plenty of new friends during the storm, and some people felt they made lifelong friends following the storm. Friends were valuable because the interviewees saw that friends contributed a lot regarding assistance. Friends helped with a place to stay, offering basic necessities, giving emotional support, and helping with the rebuilding process. Assistance came from early childhood and high school friendships, but also from strangers who became close with those relocated in Texas or the surrounding states. Some of the interviewees felt close with those volunteers who offered them church services, strangers who supplied them with food, and people from the Red Cross and local charities. Friends were an interesting trend in these interviews because people either stated they went to different states not looking to meet new friends, and that no one helped them, or that they were well received and kept in contact with those people who treated them so well.

The people who said friends didn't help them out usually moved the conversation towards feelings about discrimination, and that it was hard for them to make friends and feel welcome. As stated briefly before, interviewees discussed how some Texans associated them negatively. For example, Texans would perceive them as the dangerous looters they saw in the media, and others experienced prejudice from other states and parts of Louisiana. A 50 year-old woman stated:

"We made no friends nowhere. I don't keep in contact with any of them. In Atlanta we felt welcome, but not in Texas. In Texas they were rude. I am 50 years old. I don't entertain that type of behavior anymore or things like that."

Based on our interviews, it often sounded like people in the St. Anthony neighborhood felt they were either taken in with open arms or left out to dry. Some people blamed others for their situation, and it was hard for them to trust others. Some people did said they were not focused on making friends, because all they wanted to do was return home. A teenage boy, approximately 15 said:

"I made a few friends in Texas, but I wasn't focused on making friends. I stayed there for 2 years with my family but I missed New Orleans and we decided to come back."

When the teenage boy did come back home, he relied on friends to give him a place to stay.

Despite some unfortunate tales of meeting new people in Texas, there were quite a few success stories from people who felt very secure and protected by the helping hands they later associated as friends. Christmas cards and letters were exchanged between some people, and contact has been maintained fairly well since Hurricane Katrina and the evacuation. A young woman recalled:

"A man had called us while we were at the hotel and asked us if we had found a place to stay yet. He met up with us and he allowed us to live in a spare home in the back of his property. We stayed in that house for 6-7 months. The area was nice, and it was a Hispanic neighborhood. My mom used to keep in contact with the people we met in Houston, especially the man who helped us".

Another woman said she had a good sense of being taken care of in Texas, and made herself a lifelong friend.

It seemed that friends played a larger role in giving aid than family did. Family

was more reliable in terms of giving first-hand support, especially a place to stay, but friends seem to have helped out over a larger period of time. Friends were talked about more because they were at times an unexpected and pleasant surprise. New friends in different states exceeded the expectations some people had, and brought more support than one could have conjured on their own. Also, friends were there for emotional support. Many local New Orleans friends suffered the same tragedy so they couldn't offer anything at all, but friends aided each other by lending an ear, or feelings of empathy. They gave reassurance because they experienced the same thing, and they were there to console and protect each other around their neighborhood. Friends also helped bring together the feeling of belonging, and after Katrina, people were lacking this feeling. Friends reached out with assurance, which stayed in the minds of those in St. Anthony.

Community Cohesion

There were mixed feelings regarding the closeness of the community and the commitment of the community to restore trust and normalcy. Many of the people residing in the neighborhood of St. Anthony seemed more threatened and uncertain than before the storm regarding the safety of the neighborhood as well as the closeness of their neighbors. In light of the clean-up efforts and home restorations, people were more skeptical than optimistic about the people of New Orleans connecting to one another and creating a place where they can see past the stereotypes and crime.

Crime is one of the universal concerns for residents of St. Anthony. The crime rate has, according to the interviewees, increased in their neighborhood since Hurricane Katrina, with some attributing it to the influx of renters into a neighborhood formerly filled with home-owners. People from low-income areas are now living in the houses with supplemented money from government initiatives, creating a more diverse income demographic for St. Anthony. One interviewee accused his neighbors of selling cocaine, saying he could tell when the buyers would come by in the night. Another interviewee witnessed a drive-by shooting occurring at her neighbor's house. Whether or not their blame is accurate, the events are real, as is the fear that is apparent in their eyes as they recounted the new situations they live in.

It was almost unanimous among the interviewees that crime had gotten worse since Hurricane Katrina. St. Anthony was ethnically diverse, and the feeling of a looming threat was pervasive in all groups represented. The inhabitants who lived on the edges or boundaries of the neighborhood seemed to feel more victimized and trapped than those who were closer to the middle of the neighborhood. Those inhabitants who lived closer to the middle of the neighborhood seemed less apprehensive about their safety. Caution seems to be a second nature now in this section of Gentilly, as the general consensus states—it just is not as safe as it used to be.

One aspect that was important to the homeowners prior to Katrina was that neighbors were there to look after one another. Many interviewees talked about the elderly whom they mentioned as good friends; the elderly were friends who helped maintain respect for the neighborhood. Since the hurricane, numerous new residents have moved into neighborhoods and have brought with them drugs, loud music, large families, and a lackluster sense of building close relationships. Because many people on the block are new, there is already a disconnect between what was once a part of St. Anthony and what the original neighbors want to maintain. One young woman in her twenties stated,

"Renters mostly live here and I don't feel the sense that this is my home." This attitude is present despite the action of the local government which is taking steps such as building parks and initiating neighborhood watch programs.

Most people seemed the most hurt and disappointed talking about the community they once had. Family and friends had moved away, and they adjusted to new people changing and readjusting their neighborhood. An ambivalence about community cohesion was touched on by a small group of interviewees, which consisted of two female college students and their mother. Their home was in good repair, like many of the others on the street it resided upon. One of the students noted that she felt New Orleans used to be "like a big family- if you saw someone doing stupid, you could walk up to them and just say 'Hey! Quit it!'" Now, she added, it felt as if no one trusted each other enough to have that sort of interaction.

On one particular block in St. Anthony neighborhood, an African-American woman in her mid-thirties whose favorite neighbors had relocated or had died regarded:

"I don't think anyone is doing anything to build a sense of community. The city is dysfunctional. It is like the big easy and everyone is too laid back. It is not too organized. It is hard to help bring the community together when you have to watch your back, too."

Without friends and trust that come from the strong bonds once held on to, it is hard for people to open up to those who may be suspect especially since the crime rate in St. Anthony is so high.

There is a great want for community closeness, but the people seemed unconvinced for the time being. Most of the pessimism was communicated with those who had experienced danger and had their personal space violated. A gentleman in his mid-forties, whose house was broken into a few months prior, mentioned the gang violence and troubled youth who disturb the new parks and cause disruption in the early afternoons. He insists there is a sense of community, but sees other communities as getting more attention from local government. The St. Charles region has flourished, and the French Quarter has not changed. But St. Anthony in the Gentilly District seems to have been comparatively ignored. And the lack of attention seems to have spilled over from the governance to the very populace of the neighborhood. Uncomfortably he noted:

"There is not enough trust among the neighbors to build a strong sense of community…I do not feel safe here (in my neighborhood) at all. I am not paranoid, but I caution myself."

Joe, whom we interviewed previously, stated how much he still wants to keep the community alive and wants to help it prosper. He continuously grows plants and trees for his neighbors, talks to everyone, and continues everything he started before the storm. Racial tensions and feeling isolation from other people are also common. The elderly gentleman said,

"I don't think the community is going to change. New Orleans, where I grew up is different from now. The relationships were better."

Formal or Institutional Resources

"Should I stay or should I go now? If I go there will be trouble- if I stay there will be double!" These 1982 lyrics from the music group The Clash probably weren't written with a post-disaster reconstruction scenario in mind, but one would be hard pressed to find a better-fitting statement for the situation. As St. Anthony was a middle class neighborhood, its inhabitants

had varying levels of resources to work with when the floodwaters destroyed their homes. Regardless, rebuilding after this event was going to take a substantial amount of investment to redress the loss from even the most well-to-do individuals in the neighborhood. The question is, what resources, and what amount thereof, influenced people to stay or go? Or were resources simply a piece of the puzzle that made it easier for people to return to the place they called home, which they never had any intention of leaving?

The assistance offered to the people of St. Anthony, and all of New Orleans to help get back on their feet included Road Home grants, FEMA trailers, insurance money, and Red Cross emergency funds and supplies. Many of the individuals who returned to St. Anthony, however, had much trouble with obtaining these or other resources. Some interviewees were living out of the FEMA trailer for close to a year before they had enough financial stability or assistance to fix their houses. Others had to continually take out loans due to problems with obtaining insurance money, or they had to work on their houses bit by bit as money trickled in. Others still had no problems with money, but got hurt in the long run by inadequate construction workers. A lucky few had the money, good assistance, and even some friends to help with their reconstruction.

In the first round of interviews, the data show how hit-and-miss the assistance could be. One individual lost 100% of his possessions, and got no financial assistance from any of the formal institutions. Another lost less than 20% of all possessions, yet got 120% reimbursement--effectively making money due to the storm. Yet, both returned to St. Anthony neighborhood. In reading through all of the responses there is a glaring absence of a discernible pattern or even an 'average' amount of resources that each interviewee had. Some had lots, some had a little- some had an easy time of getting help, some went to hell and back to gain anything at all. Through this, another piece of the puzzle seems to be gained. It must have been something else that drew people back to the mostly destroyed area of St. Anthony, still at risk of another flood, and now with more crime. We now know that people would fight tooth and nail to regain their home.

Discussion

The snippets of narratives presented here can be used to support the notion that individuals shared similar reasons for returning to New Orleans following Hurricane Katrina: a call to come home because of belonging, and a call to home because of refuge and understanding. These reasons came during the midst of loss and misfortune following the Hurricane. However, in reading through all of the responses, it is also clear that there was a wide array of resources that each interviewee had lost. In order to gain anything back at all, there was the long and difficult process to attain FEMA aid and Road Home financial support or fight the insurance company. A majority of the views about formal assistance were negative when interviewees were asked about being taken care of. The importance of a sense of being taken care of, first hinted at in the first round of interviews, is still being investigated and may be linked to higher rates of formal assistance. While the distant friends and family may have a significant role to play in this feeling, the government was perceived as unreliable and inconsistent and the insurance companies uninterested in taking care of those interviewed. Money was in high demand and there wasn't enough to go around for the people in the community.

Views lightened up when the people of St. Anthony talked about assistance from

strangers and friends. Whether people relocated further away from home or not, people were grateful for any aid. There was a difference in the types of aid received by family and friends. If the interviewees had family they had previously kept in contact with, those relatives gave assistance. The most common aid given was a place to stay but family hardly gave money. Additionally, lifelong friends gave less assistance compared to the strangers who later became good friends with the citizens of St. Anthony. Most of the interviewees were surprised at the amount of aid they received from strangers and charities. The interviewees made new friends and seemed to establish deeper connections with people who they met when they relocated as opposed to bonding with the people in their own community. Remembering Kaniasty et al.'s (2011) finding that friends and family gave less than our interviewees expected of them, and that these new, 'foreign' friends gave relatively much, we may understand why these deeper connections came about.

When the people of St. Anthony explained their experiences with discrimination and prejudice, they talked about it with nonchalance. African-American or Caucasian, both groups felt disfavored when they relocated after the storm, or when they returned home. Most of the people of St. Anthony who had experienced discrimination or prejudice in parts of Texas, Alabama, or Mississippi did not feel very resentful for any mistreatment they had received. The victims were only concerned about coming home and returning to normalcy. Returning to New Orleans meant reconnecting themselves to the community they were attached to. It was the desire to be at ease with their home and community that seemed to draw people back to the crime ridden, destroyed area of St. Anthony.

The sense of community in St. Anthony seems more detached today compared to before the storm. Residents are more separated, and there is a heightened risk in the neighborhood regarding safety. Yet, rediscovering a place to belong overpowered all the negative associations with New Orleans. The data showed that even those who had a positive experience in another state and felt they were well taken care of still longed for the time they could return home. The neighborhoods were a burden to rebuild, and it disturbed the people of St. Anthony emotionally and physically. Still, the interviewees displayed a continuous eagerness to repair the city they loved and cared for, even six years later, echoing the ideas in Livingstone's essay- this is their place, where they would not have to face a new social environment as shown by Lein et al. (2009). It might be inferred that the assistance from friends and family gave the people of St. Anthony greater emotional fortitude and added to the latter's devotion to New Orleans. The study only covers one neighborhood of New Orleans, however. Further studies will be needed to see if different locations viewed their neighborhood or their city with any more, or less, devotion and care.

Conclusion

Examining the interviews, we can easily walk away with an appreciation that each disaster experience--like the individuals who experienced them--is unique. This applies to both the events during Katrina, and the long journeys that followed them. The trick in answering 'why return?' lies in identifying the universals that permeate between these tales. Differences are common in the experiences in evacuation sites and the amount of resources received. As such, it would seem that positive and negative experiences, along with wealth or debt, are simply asides to the true draw of home. However, the importance of friends, family, community are all seen throughout

the stories, either through the lament of losing them, the hope of regaining them, or the joy of returning to them. It is here, then, that we possibly find our answer to what is worth going through to come back to New Orleans; what is worth going through to come back home.

References Cited

Gill, D., Picou, J., & Ritchie, L. (2011). The Exxon Valdez and BP oil spills: A comparison of initial social and psychological impacts. American Behavioral Scientist, XX(X), 1-21. doi: 10.1177/0002764211408585

Greater New Orleans Community Data Center. (2012, June 18). St. Anthony statistical area. Retrieved from http://gnocdc.org/NeighborhoodData/6/StAnthony/index.html

Hackbarth, M., Pavkov, T., Wetchler, J. and Flannery, M. (2012), Natural disasters: An assessment of family resiliency following Hurricane Katrina. Journal of Marital and Family Therapy, 38: 340–351. doi: 10.1111/j.1752-0606.2011.00227.x

Jones, E. C., Gupta, S. N., Murphy, A. D, & Norris, F. H. (2011), Inequality, Socio-economic Status, and Social Support in Post-Disaster Mental Health in Mexico. Human Organization 70(1):33-43.

Jovanovic, A. A., Aleksandric, B. V., Dunjic, D., & Todorovic, V. S. (2004). Family hardiness and social support as predictors of post-traumatic stress disorder. Psychiatry, Psychology and Law, 11, 263–268.

Kaniasty, K. Z., Norms, F. H. & Murrell, S. A. (1990), Received and Perceived Social Support Following Natural Disaster. Journal of Applied Social Psychology, 20: 85–114. doi: 10.1111/j.1559-1816.1990.tb00401.x

Kaniasty, K. (2011). Predicting social psychological well-being following trauma: The role of postdisaster social support. (Vol. 4). Washington, D.C.: US: Educational Publishing Foundation.

Lein, L., Angel, R., Bell, H., & Beausoleil, J. (2009). The state and civil society response to disaster: The challenge of coordination. Organization & Environment, 22(4), 448-457. doi: 10.1177/1086026609347190

Livingstone, M. (2007). A sense of place. Artist at Work, Retrieved from http://www.artist-at-work.co.uk/Documents/A Sense of Place.doc

Rhodes, J., Chan, C., Paxson, C., Rouse, C. E., Waters, M. and Fussell, E. (2010). The impact of Hurricane Katrina on the mental and physical health of low-income parents in New Orleans. American Journal of Orthopsychiatry, 80: 237–247. doi: 10.1111/j.1939-0025.2010.01027.x

Suar, D. (2004). Disaster and emotion. Psychological Studies, 49(2-3), 177-184.

Wakui, T., Saito, T., Agree, E., & Kai, I. (2012). Effects of home, outside leisure, social, and peer activity on psychological health among Japanese family caregivers. Aging & Mental Health, 16(4), 500-506.

Appendix- Interview Guide

Introduction:

It's been a while now since the hurricane. Would you say this disaster has changed, in some ways, how your family gets along?

Specific points to address:

- Type of aid, money or material support received?
- Who gave support and where did they live?
- Do you keep in contact with these people? How?
- Did you have a sense of being taken care of during the emergency and after? How?

About the Student Authors

Latosha Adams

is a recent graduate from the University of North Carolina Greensboro where she received her BA in Anthropology. Presently, she is interning for the Institute for Policy Studies in Washington, D.C. where her current projects involve advocating immigrant worker's rights and fighting exploitation. She is also coordinating programs and seasonal events for underprivileged and disabled children around the DC Metro Area for the Dreams for Kids organization. She hopes to pursue her Masters in International Development Anthropology or Peace Operations, and would like to continue studying the social effects of post-conflict reconstruction, recovery and development. She hopes to become more experienced to work with international interventions that aim to restore or maintain peace and stability. Her research interests include disasters, social ties and identity, and kinship.

Scott Michael Barber

is pursuing a bachelor's degree in design with an architectural technology concentration and a minor in industrial distribution and logistics at East Carolina University. He is particularly interested in sustainable design and green building. His undergraduate work has led to research in sustainability, particularly in passive solar design, and he hopes to continue research in all areas of sustainable design. His goal is to seek a Master's degree in architecture, becoming a LEED certified architect and incorporating sustainable practices in building design.

Matt Bowen

is currently seeking a BS degree in Biotechnology at the University of North Carolina at Pembroke. He is pursuing a career in Agricultural Biotechnology, where he can help farmers to develop better practices that could make farming more efficient and profitable. His experimental studies involving microbial kinetics have progressed into studying the effects of microgravity on pigment production and insect virulence of Photorhabdus luminescens.

Hannah H. Cloninger

is a recent graduate of Lenoir-Rhyne University, where she earned a BA in Philosophy and completed minors in English and Creative Writing. Her primary areas of academic interest include philosophies of identity, language and storytelling as modes of individuality, and the use of forms such as poetry and creative nonfiction to build an understanding of one's lived and narrative self. Hannah is currently taking time away from school to research and further deliberate between graduate studies in either Philosophy or Creative Writing.

Lisa C. Collins

is currently an undergraduate student at Fayetteville State University, seeking a BS in biology. She is very interested in human nutrition and fitness, and plans to attend graduate school to pursue a Master's degree in nutrition. Upon completion, she intends to become a registered dietician.

Danica Co

is currently seeking a BS degree in Liberal Studies with a concentration in Biology at William Peace University. Ms. Co is interested in scientific research and wants to pursue a career in parasitology. UNC Pembroke furthered her interest in parasitology by hosting her research internship regarding the mass production process of the entomoparasitic nematode Heterorhabditis bacteriophora and its bacterial symbiont Photorhabdus luminescens. She wishes to pursue a Ph.D. in epidemiology with a focus in parasitology which is line with her current career goals.

Breanna DeGroot

is currently an undergraduate student at the University of North Carolina Wilmington where she is pursuing a Bachelor's of Science degree in marine biology. She has been on the Dean's list and is a member of Sigma Alpha Lambda national honor fraternity. She will be graduating *cum laude* with departmental honors in May of 2013. After graduation she hopes to earn a position with the Marine Experimental Research Facility at the Mote Marine Laboratory in Sarasota Florida.

Latisha R. Edwards

is currently seeking a BS Chemistry degree with a minor in math at Fayetteville State University. She is extremely interested in toxicology and pharmacology and her goal is to pursue a career in pharmacodynamics or pharmacokinetics. Her current research focus is hempseed and its effects on the Tenebrio molitor species. She would like to pursue a MS in Health System Pharmacy and ultimately pursue a PhD in Pharmaceutical Sciences.

Garreesa Henry

is a native of the island of St. Croix in the US Virgin Islands. She is a senior at Livingstone College in Salisbury, North Carolina majoring in Biology with a minor in Chemistry. Garreesa aspires to become a pathologist. She is involved in various organizations including Zeta Phi Beta Sorority, where she serves as President, the College Pan Hellenic Council, Beta Kappa Chi Biology Honors Society, and Co-captain of the Livingstone College Tennis Team. She has received several academic awards during her college career.

Andrew J. Jester

earned a BA in English from East Carolina University, and is currently enrolled in the Master of Arts in Teaching program at the University of North Carolina at Chapel Hill. He looks forward to teaching English courses in the high school setting, and is particularly excited to employ, and continually refine, constructivist approaches to enrich the educational experiences of his students. His interest in examining constructions of knowledge, and the effects of those constructs, will be cultivated through his interactions with diverse learners. He hopes to eventually pursue a PhD in Cultural Studies and Literacies.

Daniela Jimenez

spent her formative years in Bogota, Colombia. She is currently pursuing a Bachelors of Art degree in Studio Art at the University of North Carolina at Pembroke. Her studio emphasis is printmaking and she is studying under the tutelage of Brandon Sanderson. Daniela Jimenez has participated in approximately 15 national and international exhibitions and exchanges since 2011. She was recently awarded a UNCP Undergraduate Scholar Assistantship to pursue research with a

faculty mentor. While at UNCP, she also has worked with six visiting artists in the printmaking program.

Jaehoon K. Jung

is a senior at the North Carolina School of Science and Mathematics. His work is motivated by interests in applied network theory, mathematical modeling, and macroeconomics. He hopes to extend his research in network dynamic trade models in college.

Alyse N. Kaszubski

is currently seeking a MA degree in Psychology at the University of North Carolina Wilmington (UNCW). She graduated from UNCW *magna cum laude* with University Honors and Departmental Honors in Psychology as well as minors in Biology and French. She is very interested in comparative cognition, specifically higher-order learning in non-human animals. She has spent time volunteering with the Behavioral Husbandry Department at the New York Aquarium and hopes to one day work with marine mammals in a behavioral setting.

Christopher A. Klein

is currently seeking two degrees in Economics and Finance at the University of North Carolina Wilmington. He is very interested in macroeconomics along with the equities market. His career goal is to become an investment banker and focus on macro trends that affect all markets. His studies have observed crime trends over decades and what the most efficient determinants of crime are. One of his future goals is to attain a PhD in Economics and seek a job teaching at the collegiate level.

Lindsay M. Kohl

is a graduate of the University of North Carolina at Greensboro with a BA in English and a minor in History and has been accepted to their Graduate Program in American History. Her interests are in Modern America and American Religion in Post-War Politics. She would like to thank her husband, Rick, and their four children for their love and support as she pursues a higher education and a career in teaching and writing.

Jason Kops

is currently seeking a BS in History Education and a BA in History. He is very interested in returning to his public school roots as a teacher in order to provide contemporary students with the same opportunities he was provided. He is an award-winning bartender and a member of the Guild of Sommeliers.

Elizabeth A. Locklear

is currently seeking a degree in Mass Communication with a concentration in Public Relations at the University of North Carolina at Pembroke (UNCP). She plans to continue higher education by pursing a master's degree in Communication with an emphasis in the health industry. Her research interests include the use of Native American mascots and athletic imagery in media and Public Relations fields. Currently, she is Vice President of the UNCP chapter of the Public Relations Student Society of America (PRSSA). She has served as a contributing writer for the UNCP student newspaper, The Pineneedle, and is currently the business manager for this publication.

Danielle N. Martin

is currently an undergraduate student at East Carolina University, where she is pursuing her BS degree in Multidisciplinary Studies, with a concentration in Neuroscience. In addition to her studies, she currently volunteers as an undergraduate liaison for the Sunday Fountain Clinic in Grimesland, North Carolina, and works as a research specialist in the Brody School of Medicine Department of Physiology. She aspires to continue her education by pursuing a medical degree, and hopes to integrate her interests in developmental disorders into her future career.

Chris Ann Masiello

received an Associate in General Education and an Associate in Occupational Technology from College of the Albemarle in Elizabeth City, NC. She is currently seeking a Bachelor of Arts degree in English from Elizabeth City State University in Elizabeth City, NC. One of her future goals is to attend graduate school.

Lindsay Roberts

is an undergraduate student at the University of North Carolina at Pembroke, where she is a pursuing at Bachelors of Art in Art Education. In 2012, she held a summer internship at the North Carolina Museum of Art in Raleigh and presented and pursued research at Frogman's Print and Paper Workshops on the campus of the University of South Dakota.

Ben Shoesmith

is currently seeking a degree in economics and finance at the University of North Carolina Wilmington. He is very interested in the mechanics behind macroeconomic policy and financial markets and would like to find a career that will allow him to be involved with both. To date, his work has involved basketball postseason research, crime and commodities markets. Ben enjoys trying new techniques in research and hopes to add new knowledge with each project. He would like to work on Wall Street for several years before pursuing a graduate degree in economics or finance.

Nicholson Sprinkle

is a recent graduate of the University of North Carolina at Greensboro with a Bachelor of Arts in Anthropology and Communication Studies. His interest is in the impact of culture on disaster response, both on an individual and societal level. He is presently enlisted in the United States Air Force as a search and rescue candidate. After his military career, he hopes to continue his research on geospatial networks, support, and disasters while pursuing higher education in a related field. He would like to assist in the creation of disaster response policies that utilize a culture's practices and outlooks to maximize response efficiency and minimize damage and trauma.

Wen Tang

graduated in May 2012 and received a BS in Computer Science from Fayetteville State University (FSU), and a BS in Mathematics from East China University of Science and Technology. Her outstanding academic performance earned her a spot in FSU Chancellor's List while was an exchange student from China at FSU. She is currently seeking a graduate program that will allow her to apply her background in both computer science and mathematics into solving practical problems. Her research interests are in the area of machine learning and artificial intelligence.

Reilley Thayer

is the daughter and assistant of a carpenter and uses the various printmaking techniques to employ a narrative, expressive, and symbolic voice. Having worked on farms and with tools for most of her life, she has a innate interest in craftsmanship and raw materials. She finds solace in the processes and labor of the hand-printed matrix. Currently pursuing a Bachelors of Art degree in Art Education with an emphasis in printmaking at the University of North Carolina at Pembroke, she has has participated in approximately 20 national and international exhibitions and exchanges since 2011. She was recently awarded a UNCP Undergraduate Scholar Assistantship to pursue research with a faculty mentor. While at UNCP, she also has worked with six visiting artists in the printmaking program and recently presented research at the 2012 Frogman's Print and Paper Workshops in Vermillion, South Dakota.

About the Faculty Mentors

Yufang Bao, PhD

serves as an assistant professor at the UNC Fayetteville State University. She graduated from the Fujian Normal University in China with a BS in Mathematics and later earned a PhD in Statistics and Probability from Beijing Normal University, Beijing, China and a Ph.D in Electrical Engineering from North Carolina State University, NC, USA. Her research interest is mathematical/ statistical digital image processing, and its application in medical imaging.

Michael F. Bassman, PhD

currently serves as the first Distinguished Honors Professor for the Honors College at East Carolina University. Originally from New York City, he completed his BA in French and Latin at Brooklyn College of the City University of New York. He subsequently earned his M.A. and Ph.D. in Romance philology from the University of Connecticut. Following his doctoral exams, he successfully applied for a Fulbright fellowship to Romania where he spent two years researching his doctoral dissertation. He later did post-graduate work at Columbia University (Yiddish Studies) and the Hebrew University of Jerusalem and Yad Vashem (Holocaust Studies).

Michael Behm, PhD

is an Associate Professor in the Department of Technology Systems at East Carolina University. He earned a PhD in Public Health from Oregon State University. Mike is an active member of the National Institute for Occupational Safety and Health's Prevention through Design and Construction Sector Research Councils. In 2011 he was awarded a Research Fellowship from the Centre for Urban Greenery & Ecology in Singapore to study safe design aspects of urban greenery systems. Mike is currently the Editor for the Journal of Safety, Health and Environmental Research.

Kate Bruce, PhD

is Professor of Psychology at University of North Carolina Wilmington. She is collaborating with Dr. Mark Galizio and several fantastic students to study comparative cognition in rats. In the lab, the group uses olfactory stimuli to test whether or not rats can form abstract concepts such as identity, oddity, and transitivity. Her training in animal behavior and comparative psychology has set the stage for studying learning in nonhumans from a evolutionary and functional perspective. She also directs the UNCW Honors College.

Shirley L. Chao, PhD

serves as an associate professor at Fayetteville State University (FSU). She received a BS in Biology from Duke University, a MS in Entomology/Toxicology from North Carolina State University, and a PhD in Entomology from University of California at Berkeley. As a postdoctoral researcher at the Environmental Protection Agency and the National Institutes of Environmental Health Sciences, her research areas included specific toxicants and metals and effects on developmental systems. Currently, she oversees research conducted by undergraduates and graduate students, specifically dealing with areas in hempseed and pesticides and their impact on the nervous system and development of various animal species. She is also implementing science and literacy activities into classrooms to improve literacy skills in children as well as increase the number of students interested in science.

Judith G. Curtis, PhD

serves as a tenured associate professor in the Department of Mass Communication at the University of North Carolina at Pembroke (UNCP). She earned a BA in journalism from the Pennsylvania State University, an MA in political science from Hood College, and a PhD in mass communication from the Union Institute and University. Prior to beginning her university teaching career, she worked for several decades as a professional journalist, editor, and executive in the newspaper, magazine, and book publishing industries. At UNCP, she is the faculty advisor of the student newspaper, which wins yearly awards from the American Scholastic Association and the North Carolina College Media Association. She also oversees the journalism curriculum. Her research area focuses on Agenda Setting Theory and its extension to social issues.

Michael Deckard, PhD

Michael Deckard is Assistant Professor of Philosophy at Lenoir-Rhyne University in Hickory, NC. Besides teaching modern and contemporary philosophy, phenomenology, hermeneutics, and medical ethics, he is currently working on issues in genocide in conversation with the philosopher Paul Ricoeur. He has co-edited two books, Philosophy Begins in Wonder, and The Science of Sensibility.

Wade G. Dudley, PhD

serves as a Teaching Professor at East Carolina University. He holds a BS in Social Studies (East Carolina University), an MA in Maritime Studies and Nautical Archaeology (ECU), and a Ph. D. in History from the University of Alabama at Tuscaloosa. Author of eight books and numerous chapters and articles, he specializes in Naval and North Carolina History. He also serves as faculty advisor to the Lambda-Eta Chapter of Phi Alpha Theta History Honor Society, as the Director of the Carolinas Region for Phi Alpha Theta, and on the National Advisory Board of Phi Alpha Theta.

Floyd Inman III, AAS, BS

is a Research Associate and undergraduate research supervisor for the Sartorius-stedim Biotechnology Laboratory located at the University of North Carolina at Pembroke's Biotechnology Research and Training Center. Mr. Inman graduated from Brunswick Community College with an AAS in Biotechnology (Supply, NC) and then earned his BS in Biology concentrating in molecular biology from UNC-Pembroke (Pembroke, NC). His research interests are in fermentation technology, entomoparasitic nematodes and biosecurity/biodefense. Mr. Inman is actively performing research on antimicrobial compounds that are secreted by bacterial symbionts of entomoparasitic nematodes. Currently, Mr. Inman has authored/coauthored six articles, including this work, and presented many posters, talks and lectures involving fermentation technology and entomoparasitic nematodes.

Len Holmes, PhD

is an Associate Professor of Chemistry at the University of North Carolina at Pembroke. He has mentored many undergraduate research students from both the University and partner community colleges in southeastern North Carolina. Holmes has been a leading faculty member in obtaining extramural funding related to biotechnology. His major achievement at UNCP has been the planning and completion of the UNCP Biotechnology Research and Training Center, where he has established a research lab. His research interests are in the fields of fermentation technology and agricultural biotechnology

with special emphasis on symbiosis of *Photorhabdus luminescens* and its beneficial nematode symbiont *H. bacteriophora*. His laboratory has hosted numerous international researcher collaborators and is very active in engaging undergraduate students to participate in guided research projects.

Eric Jones, PhD

is a research scientist at University of North Carolina at Greensboro, having received his doctorate at University of Georgia in ecological and environmental anthropology. Jones has focused his recent work on understanding how the structuring of social relations following extreme events (e.g., natural disasters, pioneer colonization, and immigration) impact individual outcomes and recovery. He serves as the co-editor-in-chief of the *Journal of Ecological Anthropology*, coauthored the edited volume The *Political Economy of Hazards and Disasters* (2009, AltaMira Press), published the innovative methodological piece "Extreme Events, Tipping Points and Vulnerability: Methods in the Political Economy of Environment" in *Environmental Social Sciences: Methods and Research Design* (2010, Cambridge University Press), and applied social network analysis to the study of cooperation among pioneer colonists in 'Wealth-Based Trust and the Development of Collective Action' (2004) in the journal *World Development*.

Heather N. Koopman, PhD

is an associate professor in the department of Biology & Marine Biology at the University of North Carolina Wilmington. She graduated with a BSc in Marine Biology, minor Biochemistry, as well as an MSc in Zoology from the University of Guelph, Ontario, Canada. She later earned a PhD in Environment from Duke University and followed that with a postdoctoral fellowship at Woods Hole Oceanographic Institution on Cape Cod. Her work focuses on using physiological approaches, with an emphasis on lipids, to understand marine ecology and provide data for the conservation of marine species. Animals studied in the Koopman lab range from tiny zooplankton (copepods), to lobsters, herring, seabirds, whales, porpoises and basking sharks.

Joseph S. Moore, PhD

is Assistant Professor of History at Gardner-Webb University, where he teaches courses on early America, Atlantic slavery, and civil rights. He formerly taught at the University of North Carolina at Greensboro, where he received his PhD in 2011. His research focuses on religion and slavery in the Atlantic world.

Arthur Murphy, PhD

is head and professor of anthropology, University of North Carolina at Greensboro. He received his doctorate from Temple University in anthropology. Murphy's research involves urban economic systems, as well as the cultural and social dynamics of disaster recovery. His disaster research covers floods, volcanic eruptions, and hurricanes in the United States, Mexico, and Ecuador. He is the coauthor of *Social Inequality in Oaxaca* (1991, Temple University Press), *The Mexican Urban Household* (1990, University of Texas Press), and coeditor of The *Political Economy of Hazards and Disasters* (2009, AltaMira Press).

David Luther Smith, PhD

is an Associate Professor at East Carolina University, where he teaches all levels of German language, culture and literature. His research contextualizes current debates about cultural, national and personal identity by examining the intersections

of belief, media and language theory in German texts of the early modern era.

Brandon Sanderson, MFA

has been an Assistant Professor of Art at the University of North Carolina at Pembroke since 2008. Formerly a computer programmer, his research focuses on the revival of technically complex traditional printmaking processes in the context of contemporary culture. Sanderson's artwork has been shown in over 250 solo, juried, and invitational exhibitions in the United States and abroad. During his time at UNCP, he has co-organized two national printmaking exhibitions and brought in 30 visiting artists. He has also served as a guest lecturer and visiting artist at 13 universities in 10 states.

Tatiana A. Tagirova, PhD

grew up in St. Petersburg, Russia and has lived and studied in Pennsylvania, Georgia, and Puerto Rico. She obtained her PhD in Caribbean Literature and Linguistics at the University of Puerto Rico, Rio Piedras Campus. Among some of her scholarly publications are those on Claude McKay, Frantz Fanon, Derek Walcott, Jacques Roumain, Ralph de Boissire, Rosario Ferr, and Patrick Chamoiseau. She is the co-editor of Critical Perspectives on Caribbean Literature and Culture (Cambridge Scholars Publishing, 2010) and the author of Claude Mckay's Liberating Narrative:Russian and Anglophone Caribbean Literary Connections (Peter Lang, 2012).

Dan Teague, PhD

is an Instructor of Mathematics at the North Carolina School of Science and Mathematics, where he has taught since 1982. Dan holds a PhD in Mathematics Education from NC State University. He has recently completed a term as 2nd Vice-President of the Mathematical Association of America and currently serves on the MAA Board of Governors as Governor-at-Large for High School Teachers. His areas of special interest are in mathematical and statistical modeling, and in the applications of complex systems and networks.

Julianne Treme, PhD

Is Assistant Professor of Economics in the Cameron School of Business at UNC Wilmington. Prior to this, Dr. Treme taught at Wake Forest University from 2006-2008. Her research interests are in the field of Applied Microeconomics, with an emphasis in Health Economics. Projects include estimating the impact of the tanning tax on the North Carolina tanning industry, examining the effects of recruiting on NCAA basketball success, and exploring the gender and age effects of celebrity magazine appearances on box office revenues. She enjoys teaching, spending time with family, playing golf, running with her dogs, and NC State basketball.

Rufus Williamson, PhD

is an assistant professor at Livingstone College. He received a PhD in Microbiology from Meharry Medical College, and pursued postdoctoral studies in Molecular Biology at the University of Michigan Medical School. He worked at the Parke-Davis Pharmaceutical Research and at Pfizer Global Research Development on the Bioinformatics Research Team. He also served as an adjunct professor of Biology at Concordia University, and also taught at Eastern Michigan University and the University of Michigan. His current research efforts lie in the systems biology of bacteria, and in understanding the large scale organization of transporter complexes and their evolution in bacteria.

Submission Process

Who is Eligible?

The primary author or authors must be undergraduates at a 2 or 4 year college or university in the state of North Carolina working on original research under the direction of a faculty mentor. Works may be co-authored. Students at NCSSM are also eligble.

What to Submit?

We are seeking research papers, critical essays (literature/research reviews, articles written on a particular topic), or media submissions of performing/fine art endeavors. Text of papers should be no more than 6000 words.

Explorations, the Journal of Undergraduate Research and Creative Activities for the State of North Carolina, provides opportunities for a variety of text and media submissions in the following disciplines:

Biological, Earth, and Physcial Sciences
Business and Legal
Creative Writing and Discourse
Humanities
Mathematics
Performing Arts
Social Sciences
Technology and Engineering
Visual Arts and Design

How to Submit?

Guidelines for publication:

1. Submit all articles (without images) in Word documents (.doc or .docx) only, and indicate where images, graphs, maps, or charts should appear.

2. Submit images, graphs, maps, and charts as separate files. For creating graphs and charts (in Excel, Illustrator, or Paint): make the image as LARGE as possible. This will ensure its visibility in the publication. In addition, also save figures as images (.jpg, see below).

3. Images need to be saved as .jpgs, preferably at high resolution (300dpi).

4. If images are not yours, please obtain permission in writing and cite the copyright owner.

5. Use grayscale (no colors) on all charts, tables, graphs as *Explorations* is not published in color.

6. Submit everything in its original file. (Example: article as Word .doc, image as .jpg.) Do not convert files. Do not embed images into your article. Be sure you indicate image placement when you submit your final manuscript.

7. We ask that you have at least one faculty member other than the faculty mentor review the manuscript before you submit to Explorations. This reviewer should be well-versed in your discipline and able to provide comments to improve your paper.

8. Please attach your submission and all additional forms in an email addresed to: csurf@uncw.edu.

Suggestions for Success

1. Make sure your name is on everything you submit

2. Use your initials and submission title as the title of your paper and/or any other email attachments, this way everything can be easily identified.

3. Turn in your required forms with your submission. Submissions sent without all required forms will not be accepted. Detailed information at www.uncw.edu/csurf/explorations/ explorations.html.

4. Once your work has been approved by your faculty mentor and reviewed by another faculty member familiar with the research area, you may submit your work yourself or your faculty mentor may submit it. If you are a single author, you will be the main contact. If you are one of multiple authors, decide who will be the main contact and have him/her submit on behalf of all.

Submission Deadline for Volume VIII: June 1, 2013.